INDUSTRIAL ENGINEER

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G. A. VAN BRUNT, *Managing Editor*

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Standards of Design and Performance

with some pointers for buyers who want to get their money's worth

WHEN you go into a plant these days and talk with the engineers, superintendents and those who act as company purchasing agents, at some time in the conversation the word "standardization" will be used, and in almost every such conversation it will have from two to ten different interpretations.

The impression seems to be current that standardization is the offspring of efficiency, which some years ago was an over-worked word in the language of those who are now known as efficiency experts. Be that as it may, the fact is that "efficiency" and "standardization" are merely words in the minds and results of those who simply buy equipment of one make and put it to work without a thorough analysis of the job to be done and the results that are to be secured in terms of cost, time factors, quality and improvements in keeping with the progress of the art of which the job is a part.

Henry Ford for more than 16 years has made a road vehicle in which nearly every part today is interchangeable with every part of the original model. But today there is hardly a single part that is made of the same material or made in the same way as the original parts. This is a standard vehicle in which the construction has been standardized, but in making this standard model possible, nothing in production methods has been standardized. On the contrary, the process of production has been one of continual change in materials, machinery, and methods, so as to improve the result and bring about better quality and durability.

Today when a plant superintendent thinks he is standardizing by buying all of one make of motor, starter, instrument or any other electrical tool used in production operations, he is simply fooling himself and thinking more about the price he can get on a quantity purchase of a single make rather than about the job that he is responsible for and his need for equipment that will place him in a position to secure the best results at the lowest operating cost. First cost in any investment in plant equipment is by no means the total cost, and many a low first cost has turned out in years of service to be an excessive total cost. In the studies that have shown this to be true, durability, reliability and quality of design and materials used have been the factors that have told the tale.

The thing that plant superintendents should study these days about the production tools they buy, in addition to their use, is standards of design and construction and in these matters as regards electrical devices there is no excuse for being in the dark. On this page I am showing the cover of a publication that in almost its present form is more than ten years old and now contains 245 pages. This volume, *The Electric Power Club Handbook of Standards*, gives details of design standards for practically all electric power apparatus used in an industrial plant as made by 81 leading manufacturers. In this group, for instance, there are at least 32 that make motors, and each and every one builds motors to these standards. One motor is better than another, therefore, not because of the design standard alone, but in the quality of materials, workmanship, and ability to stand up in service.

Price alone may be used to select a design standard, but price alone can never be used with safety to select a service standard and here is where good judgement and much practical experience show up the difference between a poor buyer and a good one. Today the good buyer will not purchase an electrical or mechanical device until he has applied a rigid set of tests. It is in making these tests that standards of design should be known, so that the tests will be fair to the device.

If you want to be one of these good buyers, it will pay you to have a copy of this handbook. It can be purchased from the Secretary of the Electric Power Club, B. F. Keith Bldg., Cleveland, Ohio, at a cost of only one dollar. My advice is to secure a copy and study it—then pay for reliability and performance of equipment, not for so many pounds of copper and iron and a nameplate rating.

Practical Pete

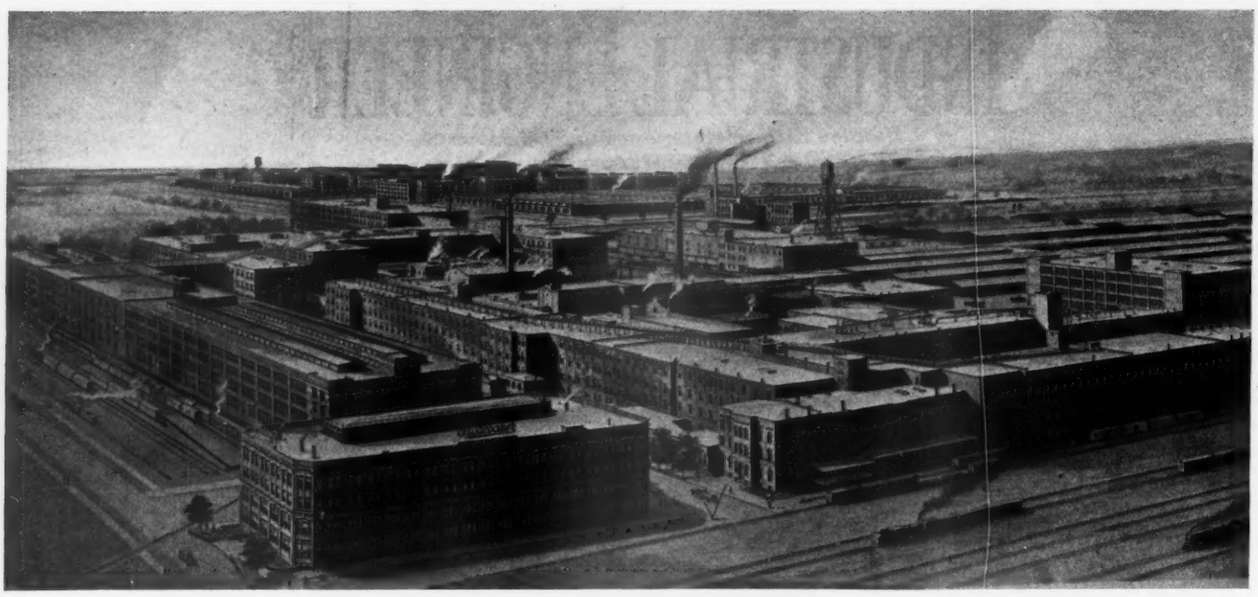


Fig. 1—Keeping the electrical equipment in operating condition in a plant of this size calls for a well-organized Electrical Department.

This illustration shows the South Bend (Ind.) properties of The Studebaker Corporation. In the foreground is Plant No. 1, while in the center background is Plant No. 2. The latter is the newer and by far the larger plant. The two plants together cover an area of more than 191 acres.

Handling Maintenance and Repairs on 4,000 Motors

and also on 700 portable electric tools, 28 battery tractors, and 35 cranes, with details of how the work is organized and responsibility delegated

By WILLIAM RASSMUSSEN
Chief Electrician, The Studebaker Corporation, South Bend, Indiana.

HIGH quality of product must not only be provided for in the design, but also must be built in during production. To enable a factory to produce a high-quality product, the equipment must be maintained in perfect order. As one of our most prominent automobile manufacturers puts it, "The first duty of management is to keep the tools in shape. By the tools is meant the entire plant and everything pertaining to it." This requires an organization that understands the requirements of the equipment, how it should be installed to obtain the most satisfactory results, what routine inspection and maintenance is required, and how it may be repaired in case of breakdown or failure.

To obtain an idea of the scope of operations of the electrical maintenance and repair organization of the Studebaker plants at South Bend, Ind., let us consider the extent and character of these plants.

There are two plants at South Bend, which together cover an area of 191 acres. A bird's-eye view of the two plants is shown in Fig. 1. Plant No. 1 makes springs, small forgings and stampings, windshields and all the types of bodies used on Studebaker cars. Plant No. 2 is the larger and consists of a forge shop, stamping plant, iron foundry, machine shop, stores and assembly building, final car assembly building, car storage building, shipping building and power house. The diverse character of the different operations carried on in these plants is readily apparent.

In the two plants there are over 4,000 motors ranging in size from ⅛ to 700 hp., together with about 700 electric portable hand tools. To furnish the power required by this scale of operation, there is a power house with turbo-generator capacity of 16,000 kw. Power is generated at 2,300 volts, three phase, 60 cycles and carried underground by means of lead-covered cables to substations near the various load centers of the plant, where it is transformed to 440 volts a. c. and converted by motor-generator sets to 220/110 volts d. c. for power, and stepped down to 220/110 volts, a. c. for lighting. The total connected power load of the two plants is 28,366 kw., and the total connected lighting load is 4,050 kw.; this gives a total connected load of 32,416 kw. The maximum demand is about 14,000 kw. and the average power consumption per month is about 4,000,000 kw.-hr.

To operate, maintain and repair the electrical equipment that has just been briefly outlined requires an Electrical Department consisting of a force of 140 to 160 men, under the supervision of the Chief Electrician. A chart of the organization of the Electrical Department is shown in Fig. 6. As will be seen, there are two Assistant Chief Electricians, one in charge of each plant, both of whom report to the Chief Electrician. Under each of these men are straw bosses who are in direct charge of the various divisions of the department. Let us consider the duties and responsibilities each of these in turn.

Maintenance Electricians.—In this division there are 18 men in Plant No. 2 and 9 men in Plant No. 1. In Plant No. 2 these men are assigned as follows: enameling dept., one man; foundry, four men; forging department, two men; machine shops, three men; sub-assembly, three men; stamping department,

one man; and general, four men. These men are located as shown so as to be close to the trouble calls that originate in their departments.

Instead of having lengthy records and reports to check off as to what he has done or should do, the responsibility of keeping his own department running is placed squarely up to each man. This gives each man a feeling of pride and an incentive to make a good showing. A check on their work is made by means of the *Call Record* which is shown at *F* of Fig. 4. Whenever electrical trouble occurs, a telephone call is sent to the maintenance man in charge of that department. The time that the call was received and the location of the faulty machine are entered on the form. The maintenance man going out on this job, enters his name and the time he left in the proper columns. When he returns he enters the time of his return, together with any remarks that may be necessary. One of these forms is made out each day for every group of maintenance men serving a given department. These records go to the Assistant Chief Electrician every night, so that he has a complete record of all trouble calls, how soon they were answered, and how soon the trouble was corrected. Inasmuch as each maintenance man also makes a note on this same form each time that he goes on an inspection trip, naming the installation inspected, a complete record of the activities of all of the maintenance men is available from this form. The form is very simple, involving a minimum of paper work on the part of the maintenance man, which is a decided asset.

Studebaker

ELECTRICAL MOTOR RECORD

INSTRUCTIONS:—Made in Original by Electrical Department, from purchase invoices, stores requisitions and time tickets Filed for reference.

Make General Electric | Equip. No. 20036
Type AT 731-4-5-1800 | H. P. 5
Voltage 440 | Amp. 7.05
R. P. M. 1720 | Frame 731
Mfg'rs Ser. No. 3191315 | Style Form C

Date Installed	Dept. No.	SERVICE	Date Removed	CAUSE	REPAIRED Date	REPAIRED By Whom
11-1-22	104	Bridge RT 186-242	2-26-23	Bearings	3-27-23	5 & 5 for Bearings
11-1-22	104	Grinder Track Table	4-14-23	Bearings	6-17-23	Overhauled by Motor Dept
11-1-22	104	" "	10-23-24	Bearings	10-31-24	5 & 5 for Bearings
11-19-23	104	" "	10-23-24	Armature Burned	1-2-25	5 & 5 " "
11-5-24	304	Spray Booth Fan	1-9-25	Bearings	2-12-25	Repaired by Motor Dept
1-10-25	304	" "	11-1-25	Burned out	11-25-25	5 & 5 for Bearings

MOTOR DATA
Cost of Motor
Freight
Cost of installation
Purchase Order H-18928
Size of pulley
Dia. of shaft 1 1/8"
No. of bearing #38/1877
Size of wire #17 D.C.C.
Connection Lap & Cy Delta
No. of coils 36
No. of form for coils
No. of turn in coils 39
Span 1-8
Size of insulation
No. of drawing
3 Belts per group
12 groups

Fig. 2—This card is the basis of the motor record system.
On it are placed the complete nameplate data of the motor, the equipment number that is assigned to it, motor repair data, and a record of its service, including cause of failures. There is also space for giving the nature of the repairs, together with the name of the man or department that made them.

When there are no trouble calls on hand, the men are expected to make regular rounds of the equipment under their care, inspecting bearings, commutation, heating and general operation of the motors, control and other electrical equipment.

It will be noticed that in the assignment of men, four were marked general. Three of these are crane inspectors and repair men. They spend their entire time inspecting, maintaining, and repairing the 35 cab controlled cranes and 80 electric hoists varying in capacity from ¼ to 3 tons, all of which are located throughout the plant. Not only is the Electrical Department responsible for the electrical equipment of the cranes, but also it does all of the mechanical repair work on them that is required.

A more detailed inspection report is required of the crane inspectors. The form used is shown at *G* of Fig. 4. The vertical columns are for the individual cranes inspected and on the horizontal lines are listed the parts inspected.

Daily inspection of all equipment is not attempted, because the duty is not so severe as to warrant having a gang of maintenance electricians large enough to do this. At week ends, overhauling and more thorough inspections are conducted.

Electric Repair Shop.—There are two electric repair shops, one in Plant No. 1 and the other in Plant No. 2. The former is devoted almost entirely to rewinding, repairing and otherwise maintaining the electric portable tools. All manner of repairs are made to these tools; in fact, they are rebuilt from stock parts whenever necessary. Armatures having form-wound coils are specified when the tools are purchased. This type of winding has been found more satisfactory for the service to which they are subjected in these plants; also they are much easier to rewind.

Three men are required in this shop for handling this work. A corner of the repair shop is shown in Fig. 5. A small precision lathe for turning commutators and doing what other lathe work may be necessary on the portable tools, together with a small press for pushing out armature shafts, are the main pieces of equipment required. Inasmuch as no machine winding is used and the form-wound coils are

Fig. 3—Repair shop for the electric industrial trucks and tractors.
In this shop are made all mechanical and electrical repairs and inspections that may be required on the fleet of 28 trucks.

purchased, no coil winding equipment is required for this particular class of work.

The main electric repair shop is in Plant No. 2. In this shop all other motor repair as well as control repair work is conducted. Aside from the general run of electric repair work, about 500 armatures are rewound per year. Five men are continuously employed in this shop.

For winding and forming coils, a Segur coil winder and a Segur coil former are provided, as shown in Fig. 10. All mush coils are wound in the shop and, in addition, any other coils that might be required in an emergency. A large stock of coils is carried in the electrical storeroom to meet the usual rewinding demand.

Stators are stripped by burning out the old winding. This is a rather rough method, but it serves

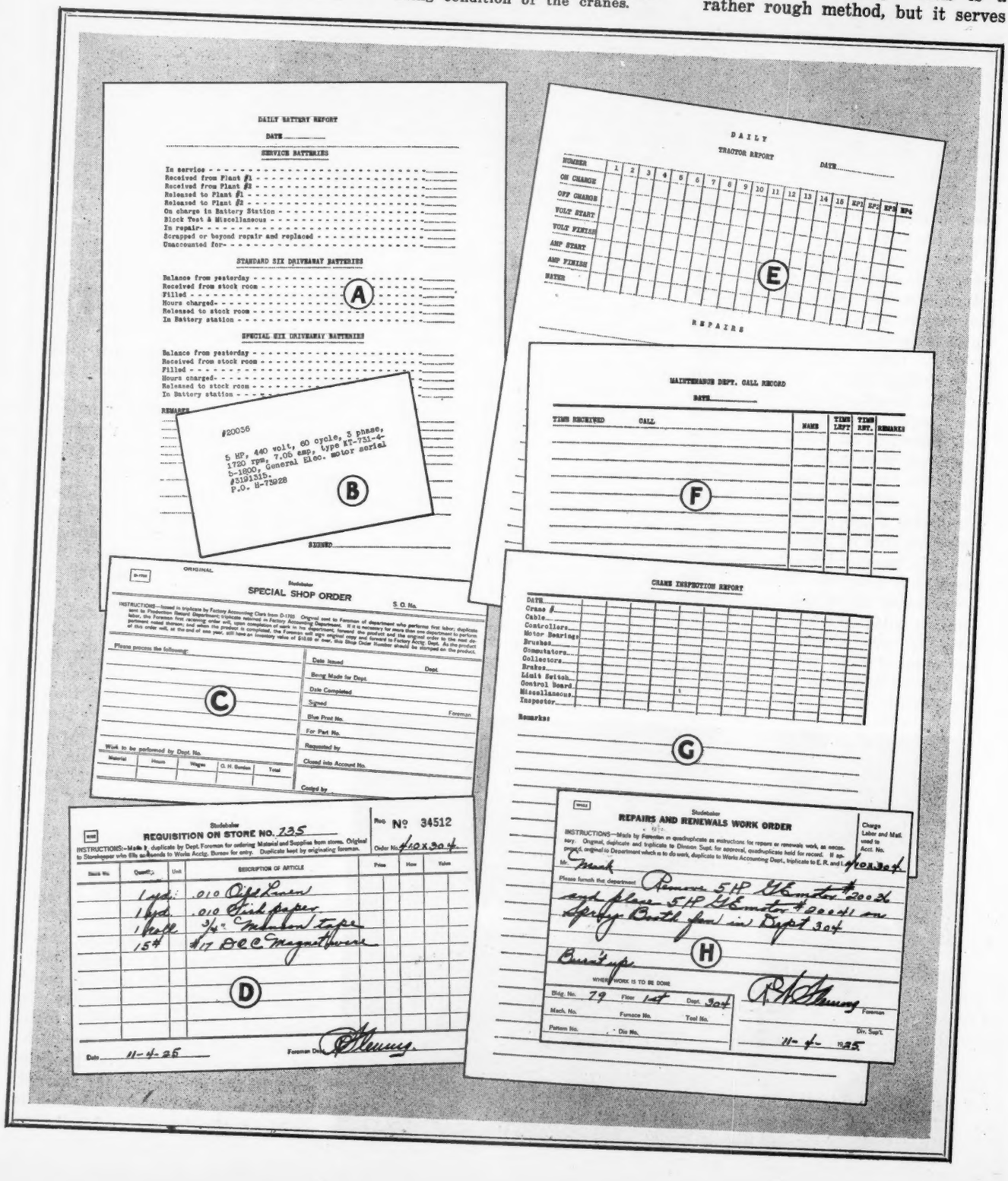

DAILY BATTERY REPORT
DATE
SERVICE BATTERIES
In service
Received from Plant #1
Received from Plant #2
Released to Plant #1
Released to Plant #2
On charge in Battery Station
Block Test & Miscellaneous
In repair
Scrapped or beyond repair and replaced
Unaccounted for
STANDARD SIX DRIVEAWAY BATTERIES
Balance from yesterday
Received from stock room
Filled
Hours charged
Released to stock room
In Battery station
A
SPECIAL SIX DRIVEAWAY BATTERIES
Balance from yesterday
Received from stock room
Filled
Hours charged
Released to stock room
In Battery station
REMARKS
SIGNED
#20036
5 HP, 440 volt, 60 cycle, 3 phase, 1720 rpm, 7.05 amp, type KT-731-A-5-1800, General Elec. motor serial #3191315. P.O. B-75228
B
DAILY TRACTOR REPORT
DATE
NUMBER
ON CHARGE
OFF CHARGE
VOLT START
VOLT FINISH
AMP START
AMP FINISH
WATER
REPAIRS
E
MAINTENANCE DEPT. CALL RECORD
DATE
TIME RECEIVED
CALL
NAME
TIME LEFT
TIME RPT.
REMARKS
F
ORIGINAL
Studebaker
SPECIAL SHOP ORDER
S. O. No.
INSTRUCTIONS—Issued in triplicate by Factory Accounting Clerk from D-1703. Original sent to Foreman of department who performs first labor; duplicate sent to Production Record Department; triplicate returned in Factory Accounting Department. If it is necessary for more than one department to perform labor, the Foreman first receiving order will, upon completion of work in his department, forward the product and the original order to the next department noted thereon; and when the product is completed, the Foreman will sign original copy and forward to Factory Accg. Dept. As the product of this order will, at the end of one year, still have an inventory value of $10.00 or over, the Shop Order Number should be stamped on the product.
Please process the following:
Work to be performed by Dept. No.
Material
Hours
Wages
O. H. Burden
Total
Date Issued
Dept.
Being Made for Dept.
Date Completed
Signed
Foreman
Blue Print No.
For Part No.
Requested by
Closed into Account No.
Costed by
C
CRANE INSPECTION REPORT
DATE
Crane #
Cable
Controllers
Motor Bearings
Brushes
Commutators
Collectors
Brakes
Limit Switch
Control Board
Miscellaneous
Inspector
Remarks
G
Studebaker
REQUISITION ON STORE NO. 135
No. 34512
INSTRUCTIONS:—Made in duplicate by Dept. Foreman for ordering Material and Supplies from stores. Original to Storekeeper who fills and sends to Works Accts. Bureau for entry. Duplicate kept by originating foreman.
Order No. 410x304
Stock No.
Quantity
Unit
DESCRIPTION OF ARTICLE
Price
How
Value
1 yd. .010 Oil Linen
1 yd. .010 Fish paper
1 Roll 3/4" Mellow Tape
15# #17 B&C Magnet wire
D
Date 11-4-25
Foreman Dept. R. H. Stenning
Studebaker
REPAIRS AND RENEWALS WORK ORDER
Charge Labor and Mat. used to Acct. No.
INSTRUCTIONS—Made by Foreman in quadruplicate as instructions for repairs or renewals work, as necessary. Original, duplicate and triplicate to Division Supt. for approval, quadruplicate held for record. If approved, original to Department which is to do work, duplicate to Works Accounting Dept., triplicate to E. R. and I.
Mr. Mack
Please furnish the department
Remove 5 HP Hamilton #20026 and place 5 HP Hamilton #20241 on Spot by Both feed in Dept 304
Burned up
H
WHERE WORK IS TO BE DONE
Bldg. No. 79 Floor 1st Dept. 304
Mach. No.
Furnace No.
Tool No.
Pattern No.
Die No.
Foreman
Div. Supt.
11-4- 1925

Fig. 4—Records that keep the department head informed as to the progress of work being done.

At *A* is shown the daily report of the battery maintenance section. *B* is the record of equipment numbers assigned to the motors. *C* is the form used for authorizing all new installation work. The form shown at *H* is similar except that it is issued for repairs and renewals. Material is taken from the storeroom on the form shown at *D*. *E* is the daily report of the tractor maintenance section. *F* is the report of all calls received by the general maintenance men. *G* is the crane inspector's report showing the operating condition of the cranes.

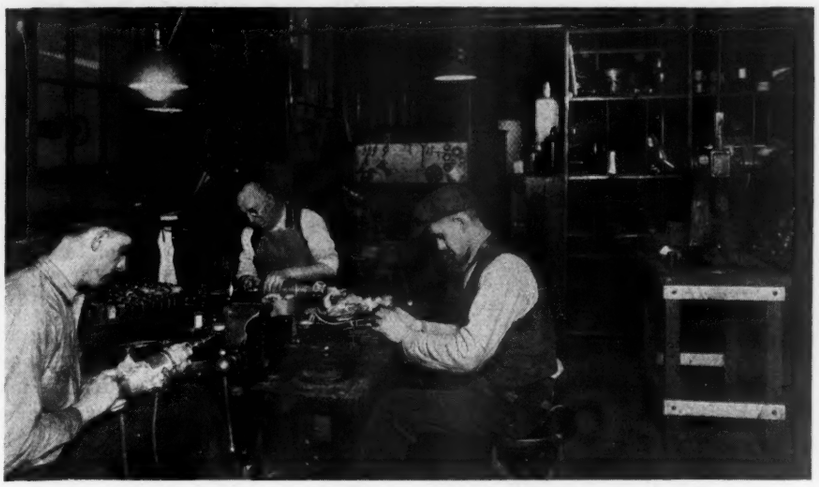


Fig. 5—This is a corner of the shop where all repairs required by 700 portable electric tools are made.

At the right is a small press for pressing out armature shafts. In the center background is shown a small precision lathe used for turning commutators and doing any other machine work required in making repairs on the tools. Note the circular compartment drawer for holding the many small repair parts, shown at the left on the workbench.

the purpose. A corner of the shop where the armatures and stators are wound is shown in Fig. 8. At the rear is the storage rack for stock and repaired armatures.

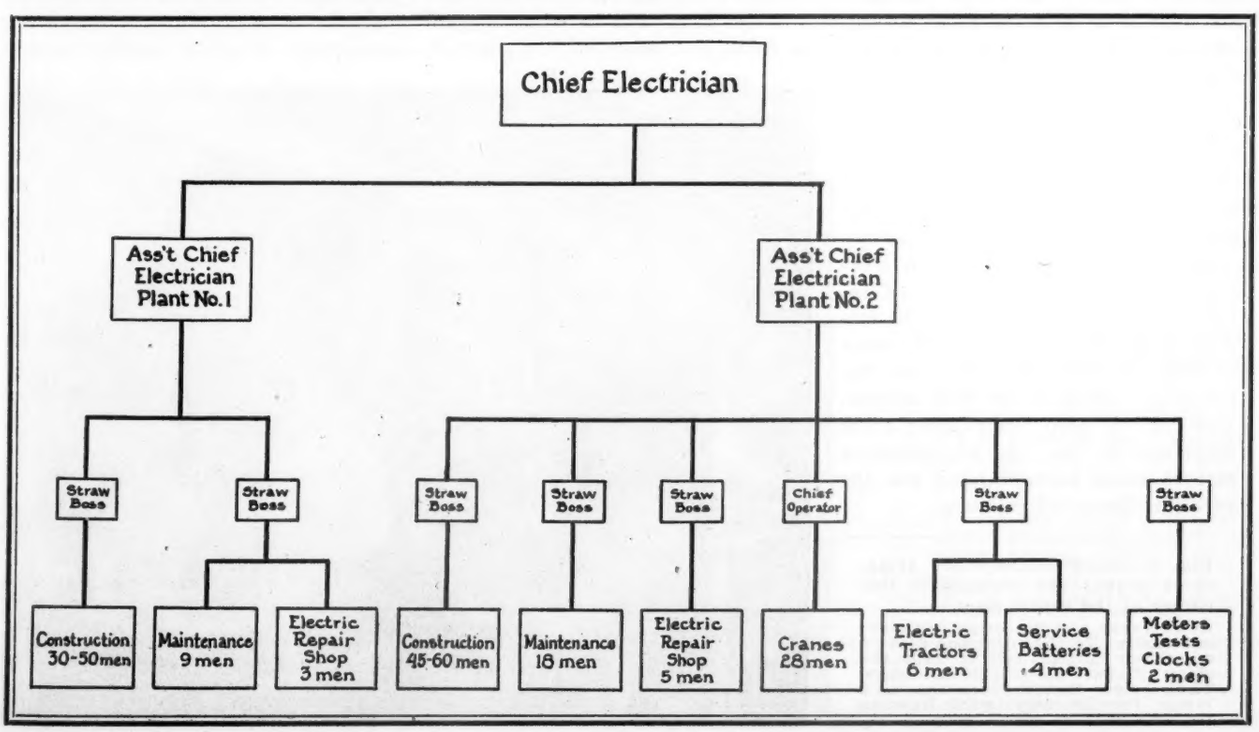
After the machines are wound they are tested for shorts and grounds. They are then preheated in the baking oven shown in Fig. 10 for 12 to 16 hr. This baking oven is equipped with a pyrometer which automatically holds the temperature at 220 deg. F. The stators or armatures, as the case may be, are then removed and dipped while hot in amber baking varnish. The arrangements for doing this are very convenient. The machines are on a small car while in the oven. This car is pulled out and the machines lifted out of the car by a small chain block which is carried on a light trolley travelling on an I-beam. By means of this small monorail hoist, the machine is carried directly back from the oven to the dipping tanks, which are just to the right of the field of view in Fig. 10. These tanks are cubical in shape, measuring about 4 ft. each way, and are arranged with hinged covers to prevent undue evaporation of the baking varnish solvent. One tank contains amber baking varnish while the other contains black elastic baking varnish. By means of the hoist the machine is held over the tank to drain and is then placed on the car and into the oven and baked for 12 hr. It is then removed from the oven and dipped in black elastic baking varnish and baked for 16 hr.

Many industrial plants have some atmospheric conditions that are the cause of a majority of the motor failures. In this plant the troublesome condition is the dust from grey iron castings in the machine shops where work is done on this product. This dust is very fine and causes trouble similar to that experienced from carbon, coal, and coke dust in steel mills and coke plants. Trouble from this source has been greatly reduced by the use of a plastic compound which is put over all exposed portions of the windings.

After a motor has been rewound, it is given a running test at no-load.

The foundation of the system of keeping track of the 4,000 motors in this plant is the *Electrical Motor Record* card shown in Fig. 2. This record is kept by the repair shop foreman and is located in his office. At the time of requisitioning or ordering a motor from a motor

Fig. 6—How responsibility for the proper functioning of an electrical department is divided among an organization of 160 men, is shown in this organization chart.



manufacturer, an equipment number is assigned to the motor. This equipment number corresponds to the shop number used in other motor record systems. This number is placed on the requisition and upon the purchase order and the motor manufacturer is requested to stencil the number on the motor frame in white paint. When the motor arrives this number identifies it as belonging to a specific job.

Upon the receipt of the motor an aluminum tag bearing this equipment number is riveted to the motor frame. Also, the full nameplate data are recorded in the upper right-hand corner of the card, as is shown in Fig. 2. The equipment number and the manufacturer's serial number as given by the nameplate, form a means of completely identifying the motor. The other data taken from the nameplate are the manufacturer's name, type of motor, voltage, speed, horsepower, ampere rating, and frame number.

On the first line and at the left of the form shown in Fig. 2, the date of receipt of the motor is entered, together with the number of the receiving slip. As soon as the motor is installed the date of the first installation is entered on the second line, together with the number of the department in which it is placed and the name of the machine or lineshaft that it drives.

These motor record cards are filed in two groups—one group containing the motors that are installed and operating and the other group containing the cards for the motors that are spares or in stock. The cards in each group are filed vertically in a standard filing drawer and are grouped in sections according to horsepower. The cards in each horsepower section are filed serially according to the equipment number.

When a motor is taken out of service for any reason, the date of removal is marked in the fourth column of the *Motor Record Card* shown in Fig. 2 and the cause of the removal is given in the fifth column. The card is also transferred from its place in the file of operating motors to a file arranged for the cards of the stock motors.

If repairs have to be made to the motor, the date of completing the repairs is entered in the sixth column, and in the seventh column is placed the number of the department or the name and check number of the man making the repairs. This permits fixing the responsibility for faulty repair work.

When the motor is in the repair shop for rewinding or similar repairs that require dismantling it, the motor data given in the column at the extreme right of the *Motor Record Card* are filled in. These data serve as a check on future repair jobs on the motors.

Authority to change, replace or repair equipment is given in the *Repairs and Renewals Work Order* shown at *H* of Fig. 4. Instructions for using this form are given at the top of the form. This form tells what work is to be done, what department is to do it, where the work is to be done, and to what account the labor and material are charged.

COST RECORD OF MOTOR REPAIR

1 yd. .010 oiled linen	$.54	5 hp. Gen. Elect. motor
1 yd. .010 fishpaper	.10	Type KT-751-4-5-1800
1 roll ¾ in. Manson tape	.31	Serial No. 5191515
15 lb. - #17 DCC wire	4.50	Equipment No. 20036
Cost of material	$5.25	Charge 410 x 304
11/10/25 92534 3 hr.		
11/11/25 92534 9 hr.		
11/12/25 92534 6 hr.		
Total 18 hr. labor		Span 1-8
.60		36 coils
$10.80	labor	3 coils per group
5.25	material	39 turns #17 DCC wire
$16.05	total	Single Circuit Delta

Fig. 7—A cost record of the motor repair is kept on this form.
This record gives not only the cost of the labor, but also the material used and the total cost thereof.

The work order shown in Fig. 4, *H*, calls for replacing motor No. 20036 with motor No. 20041. As can be seen in the sixth line and fourth column of the motor record card shown in Fig. 2 (which is for motor No. 20036), this motor was removed on Nov. 4, 1925. As shown in the sixth and seventh columns on the same line, the motor was rewound by Cover, check No. 34, on Nov. 12, 1925. His time and the material used are charged to the account number given on the work order, illustrated in Fig. 4, *H*. The material used for this job was taken from the electrical storeroom on the form shown at *D* of Fig. 4.

To keep a check on the cost of the repair job, the foreman in charge of the repair shop keeps the record shown in Fig. 7. At the right of the form he fills in the motor description, and also the winding data. At the left is a record of the material used together with its cost, and also a record of the time put on the job, which is evaluated in hours and then into dollars. To this is added the cost of the material, which gives as a final result, the total cost of the job. These cards are filed according to motor horsepower, thus giving a permanent record of the cost of various repairs.

One other record is kept of the motors. The motor record cards which have been described in the preceding paragraphs are filed according to horsepower. Sometimes the nameplate is lost from a motor, or is very difficult to read. In such cases the equipment or shop number would

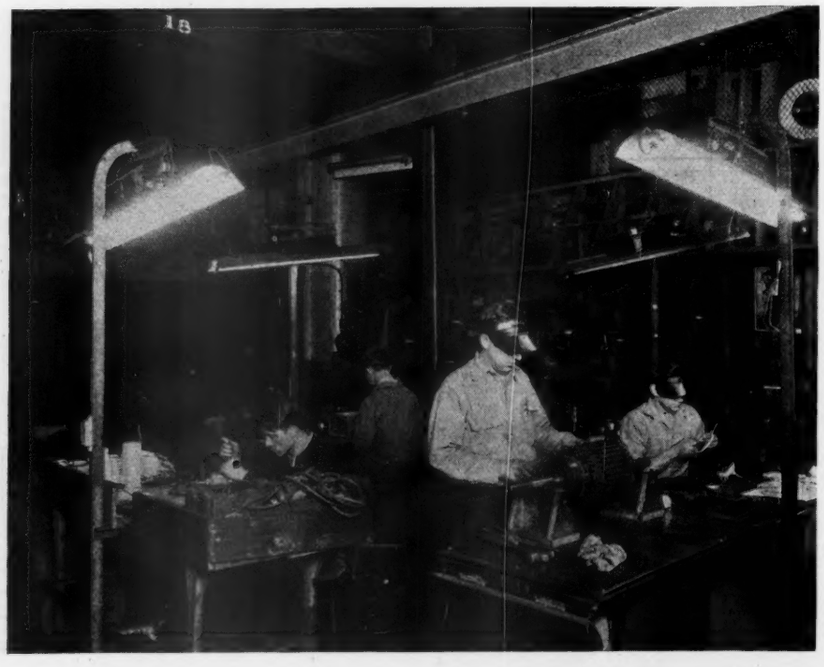


Fig. 8—Approximately 500 armatures a year are rewound in this corner of the repair shop.
At the rear are the armature storage racks. To the right and also on a balcony at the left is kept the stock of spare and repaired motors. The Cooper-Hewitt mercury arc lamps furnish very good lighting for an armature repair shop.

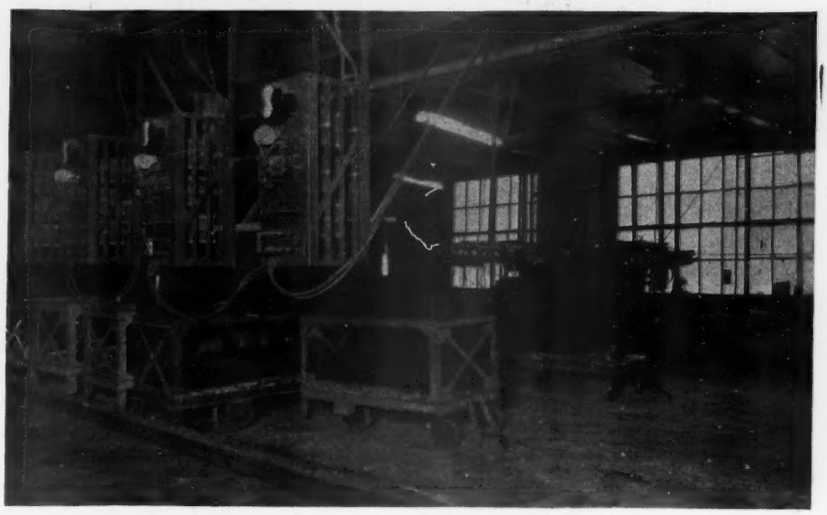


Fig. 9—Battery charging and repair is done in this shop, which is also a part of the Electrical Department.

At the left are four of the 14 charging panels used for the batteries of the industrial trucks. In the background is the charging panel which is used for charging the service batteries that are used temporarily in the cars after assembly. These service batteries are repaired and rebuilt at the bench to the right of the charging panel.

be the only clue as to the characteristics of the motor. Hence, another record of equipment numbers is kept for motors; this is the form shown at *B* of Fig. 4. These cards are filed serially so that it is easy to locate the complete nameplate data of the motors.

Cranes.—There are 35 traveling cranes in the plant, most of which are of light capacity, many of them being monorail cranes. In addition, there are 80 electric hoists varying from ¼ to 3 tons in capacity, all of which are floor controlled. The Electrical Department supervises the operators of nearly all of these cranes. There are 28 crane operators and a chief operator who is their direct superior. As has been explained previously, all of the mechanical and electrical maintenance and repair work on these cranes is done by the Electrical Department.

Industrial Trucks.—A large amount of trucking is done in the plant. A good share of this work is done by 28 industrial electric trucks or tractors. These are serviced and repaired by the Electric Department. To do this requires a small shop, a corner of which is shown in Fig. 3, and a charging station, part of which is shown in Fig. 9. The trucks are brought to this station every night for charging—this is the reason for the large number of charging panels, only four of which are shown in the illustration. Six repairmen are engaged in maintaining the trucks, doing all electrical and mechanical repair work required except armature winding and machine work, which are sent to the electric repair shop and the machine shop respectively. These men are under the supervision of a straw boss who also has charge of the men who take care of the service batteries, which will be discussed later. The tractor report form shown at *E* of Fig. 4 is made out daily to cover the charging and repairing of the trucks and tractors.

Service Batteries.—During the assembly of a car, a battery called the service battery is placed in it for starting, lighting and ignition purposes during the time the car is under test. When the car is ready for shipment a new, unused battery is placed in it and the service battery removed. These batteries are then turned over to the Electrical Department for charging, testing, and any repair work that they may require, after which they are returned to the assembly lines for further service. A large charging panel for charging several hundred batteries at once can be seen in the center background of Fig. 9.

Just to the right of this panel is the bench at which overhauling of the batteries is done. Batteries are completely rebuilt when necessary. A daily check is kept of the service battery work by means of the *Battery Report* form shown at *A* of Fig. 4. This not only gives the Chief Electrician exact information of the work being done on these batteries, but also serves as a daily inventory of the 1,443 batteries required for new car service.

Testing.—As might be expected in a plant having 4,000 motors, it is necessary to make a large number of tests to insure that the motors are correctly loaded. Many of the motors drive lineshafts and adding to or removing machines changes the loading thereon. Also, frequent production changes or changes in the car design may call for different

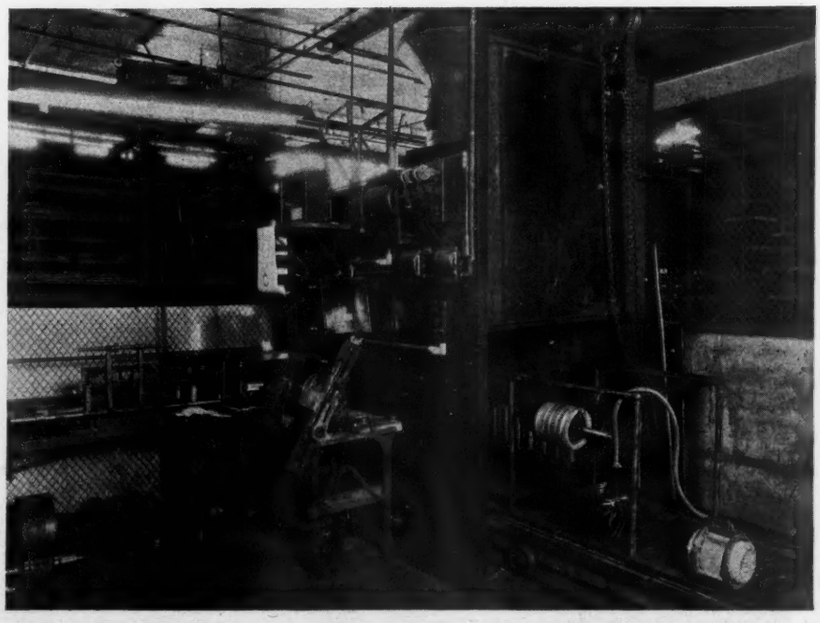


Fig. 10—All rewound armatures are given successive dippings and bakings in two kinds of varnish.

The temperature is maintained constant at 220 deg. F. by a pyrometer that automatically regulates the heating of the oven. At the left is the Segur coil winding and forming equipment used for coil making. At the end of the bench on which the motor-driven coil winder is placed, is a small, electrically-heated oven for baking small pieces. Directly above this oven is the control for the winder motor, above the controller is the pyrometer for the large oven.

work from the machines, which may change the motor loading. Inasmuch as the larger number of motors are of the squirrel-cage type, it is essential that they be loaded to somewhere near their rated capacity so as to obtain as high power factor as possible. In this connection it might be said that the plant power factor averages 75 per cent, which is very good, considering the large induction motor load carried.

One man devotes all of his time to making tests. He has the following test equipment at his disposal: four voltmeters of various ranges, some for a. c. and the others for d. c. work; five ammeters of various ranges, some for a. c. and others for d. c.; a complete set of instrument transformers and ammeter shunts; one Megger testing set; one rotating standard watt-hour meter for checking the various watt-hour meters around the plant; one foot-candle meter; one Wheatstone bridge; one graphic wattmeter; one graphic voltmeter; and one graphic power factor meter.

In the main, tests are made to determine loading and power factor. For this work the Esterline-Angus graphic instruments mentioned previously give a chart record that may be kept for comparison with later developments. Whenever any trouble develops that the maintenance man cannot correct he puts in a call for the tester. If the test shows that a motor of different rating is required, a motor of the correct rating is installed and a duplicate test is made to check the installation.

Frequent tests are required in some departments because of the possibility of increased load due to changes in the production equipment. This is particularly true in the machine shop. Practically all of the motors in this department drive lineshafts. The control for these motors is grouped at four different locations. At each location is installed a distribution switchboard such as is shown in Fig. 11. This board controls 30 motors. As may be seen, the switches are grouped in pairs, one being the starting switch and the other the running switch. These switches are served by two sets of buses, the running switches being fed from a 440-volt, alternating-current supply, while the starting switches are fed from an auto-transformer which supplies the correct starting voltage for the motors. With this arrangement only one auto-transformer is required for starting duty on the 30 motors.

An Esterline-Angus graphic wattmeter is located at each end of the switchboard and is so connected with the double bus system that it may be readily switched in so as to measure the load on any one of the 30 motors. Tests are made upon any motor that gives cause for suspicion and routine tests are made on all motors on this board at least once every three months.

The tester has one man whom he may call upon for aid when he has more test work than he can handle. Ordinarily this man takes care of all the time clocks which are scattered throughout the plant. These time clocks, which are used for stamping on each workman's time card the time of beginning and stopping work, must be checked, every day to insure accuracy.

Construction. — The Studebaker Corporation has undergone tremendous expansion since its incorporation in 1911. In fact its investment in plants and property in 1923 was over five times as great as it was in 1911. During the period from 1919 to 1923, the amount invested in plants and property doubled.

With expansion taking place at this rate it is necessary to have an electrical construction department that is organized to carry on the installation of electrical equipment at a rapid rate. Two construction gangs are used for this work, the one in Plant No. 2 varying from 45 to 60 men, while the one in Plant No. 1 ranges from 30 to 50 men. Each gang is under a straw boss. The men in each gang are split up into small groups of two to six men, each group being under a gang leader. It is the duty of this section of the Electrical Department to do all of the installation of electrical equipment required by any changes, alterations and additions that are constantly being made in the plant. This not only involves the installation of motors and control, but also includes all wiring and conduit work, lighting, substation and transformer installation, wiring of cranes, feeders, battery charging stations and the like.

Electrical Equipment. — A word concerning the electrical equipment used might be of interest. Although there are 440 volts, three phase, a. c., 220/110 volts, single-phase, a. c., and 220/110 volts, d. c., available at almost all parts of the plant, the bulk of the motors are 440-volt, squirrel-cage induction motors. Individual drive is used in many cases, but the larger share of the drives are to lineshafts.

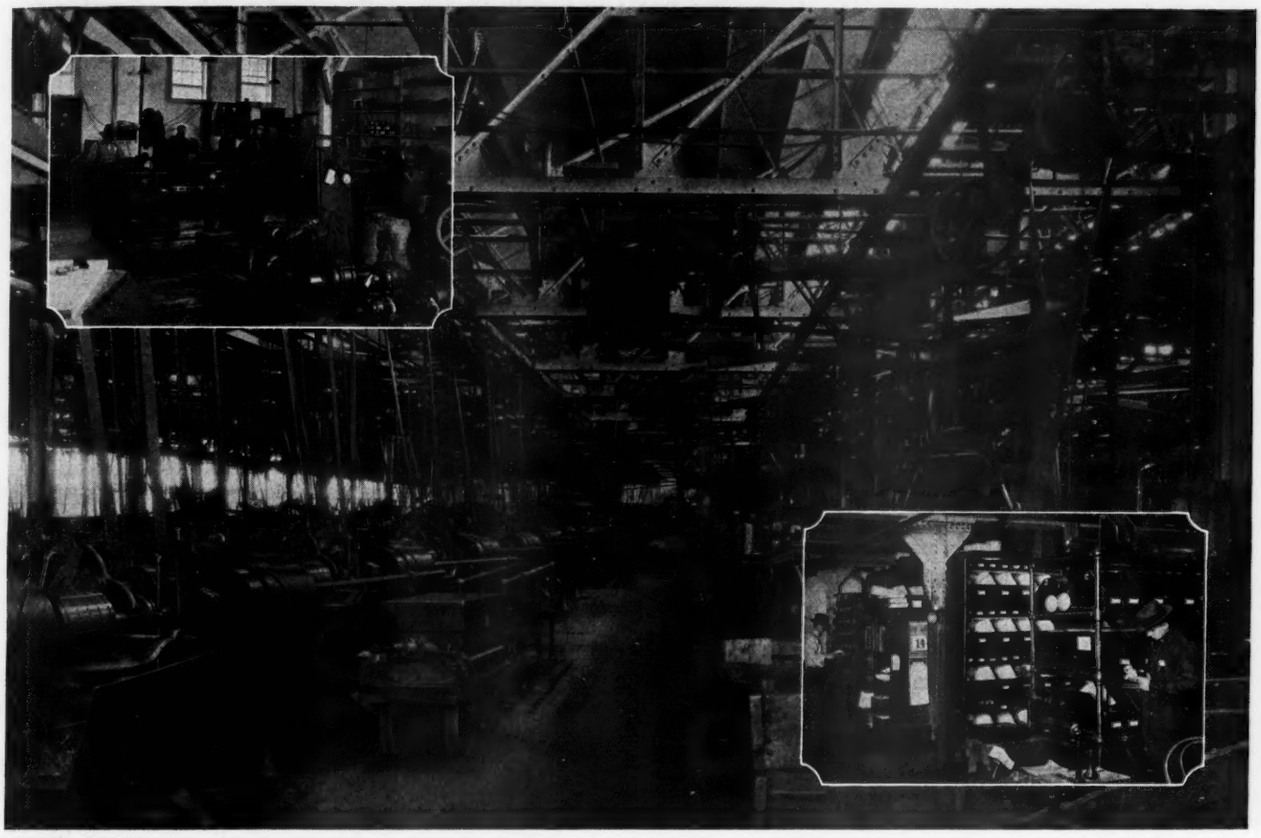
With 4,000 motors in the plant it is essential that they be standardized as to size and speed as much as possible. For lineshaft drives, motors of 30 hp. and above are limited to 900 r.p.m. speed; between 10 and 30 hp., a speed of 1,200 r.p.m. is standard; below this rating, speeds of 1,200 and 1,800 r.p.m. are used. A 50-hp. motor is the largest motor used on a lineshaft—if the lineshaft requires a larger motor, two motors are used and the load divided between two lineshafts instead of one.

Many individual drives are used, particularly in the stamping plant.

(Please turn to page 81)

Fig. 11—Here is a permanent graphic meter installation for making tests on machine shop motors.

Thirty squirrel-cage motors are controlled from this board. By means of a double bus system, the motors are all started from the same auto-transformer. Also, through the use of this bus system either of the two Esterline-Angus graphic wattmeters mounted on the end panels may be switched on to any motor for running a load check.



This is an analysis of

Maintenance Practice and Organization Methods

as applied in 80 industrial plants to the selection and care of equipment, handling of supplies, and placing of responsibility for execution of work

By G. A. VAN BRUNT

Managing Editor, Industrial Engineer

RAPID growth of industrial works during the past few decades and increasing complexity of the products made have been attended by a corresponding development of the organization and facilities for handling the maintenance work involved in keeping in proper operating condition the various kinds of electrical and mechanical equipment employed.

A great many of the old-time industrial plants, with a comparatively small number of employees and simple, engine-driven machines, have been replaced with a huge property covering many acres of ground, employing thousands of workers, and housed in great, multi-story buildings filled with complicated equipment. In the same way, the old-time "handy man" whose job it was to "fix" anything that needed attention, has been replaced with a well-organized force of inspectors, repairmen and the like, whose work is more or less specialized and is conducted largely in accordance with definite schedules. Under present conditions, with plant production carefully scheduled and controlled, and the necessity of performing every operation in the most efficient manner, in order to meet ever-increasing competition, production delays due to failure of equipment are too costly to be tolerated. Hence, the inspection and maintenance of equipment have taken their place among the most important departmental activities of a modern industrial organization.

The organization of the maintenance department, the frequency with which equipment is inspected and overhauled—in brief, the details of the methods and practices followed in properly caring for the electrical and mechanical systems in industrial plants—vary to a considerable extent with the conditions that exist in a given plant. For example, in some industries such as iron and steel, food products, and so on, failure of almost any important piece of equipment may cause serious losses from damage to or spoilage of material in process, in addition to the losses that are incurred from stoppage of production. Again, in other industries the conditions of service may be so severe, due to the presence of abrasive dust, moisture, corrosive fumes, and the like, that equipment soon deteriorates to the point of failure. In all such cases, the best safeguard against equipment failures, with their attendant expense and annoyance, is thorough inspection at such frequent intervals that weaknesses in the equipment or incipient trouble of any character will be discovered before failure occurs. This may mean inspection of all important

pieces of equipment at intervals of a few hours.

In other plants the conditions of service, the consequences of equipment failures, and other factors, may be such that inspections can with reasonable safety be scheduled for much less frequent intervals than are indicated above.

In any plant, a careful study of the service requirements and the conditions under which the equipment operates, supplemented by the experience gained in operating the equipment under these conditions, will show how the work of the maintenance department can be most effectively and economically organized and conducted.

In this article there are presented the results of an analysis of maintenance practices and procedure, including stock-keeping, in 80 industrial plants, as applied to the equipment in the path of power service that extends from the substation or main switchboard through the various elements of electrical and mechanical power drive equipment and down to the spindle of the machine engaged in production. Supplementing this equipment and serving as the connecting link between production machines and departments are the various devices which are commonly termed material handling equipment. This term includes conveyors, cranes, elevators, electromagnets, tractors, and so on, practically all of which is driven or operated by electrical energy.

The plants from which the data shown in the accompanying table were obtained, are located in various sections of the country and, with few exceptions, are nationally known; they may be considered as typical representatives of the most important industries in which production processes are employed. In their scheme of organization and in their operating methods these plants reflect modern practice and sound engineering.

As will be noted from the table these plants range in size, on the basis of kilowatt-hours of energy consumed per year, from one, No. 40, a steel plant, that uses 200,000,000 kw-hr., to one that uses 60,000 kw-hr. (No. 61, a plant making rubber shoes and soles). On the basis of number of motors installed, and total horsepower rating, plant No. 40 heads the list with 3,200 motors installed, of a total rating of 170,000 hp. At the other extreme, plant No. 10, making chemicals and explosives, has 9 motors installed, with a total rating of 55 hp. In this connection it is well to remember that in some plants or industries the manufacturing processes require comparatively small amounts of power. Altogether, in the plants for which these data were given there are installed 23,228 motors with a total rating of more than 457,800 hp. Of the total number of motors installed 6,318, or 27.4 per cent are rated under 5 hp. The electrical energy consumption of the 54 plants that reported this item is in the neighborhood of 727,200,000 kw-hr. a year. There are 41 plants listed that use over 1,000,000 kw-hr. a year; 8 that use between 500,000 and 1,000,000 kw-hr.; and 5 that use less than 500,000 kw-hr. a year. Ten of the plants have more than 10,000 hp. installed in motors, while 56 have between 1,000 and 5,000 hp. installed. Thirty-two plants reporting use alternating current exclusively; 5 use direct current exclusively; and 43 use both alternating and direct current.

As to the method of connecting the motors and driven machines, belts are used in about 48 per cent of the drives (11,159 belt drives on 23,228 motors). Direct connection though solid or flexible couplings is employed in approximately 20 per cent of the drives (4,321 couplings reported). The remaining 32 per cent of drives are through gears, chains or speed reducers.

In the way of material handling equipment, the 80 plants listed have installed a total of 495 cranes of various types, 696 conveyors, 168 electric and 7 gas trucks and tractors, and a variety of other equipment.

Turning for a moment to the lighting system, the plants reporting have a total of 123,058 lamps installed. A few plants did not report the number of lamps installed, as an accurate record was not available. To keep this number of lamps in service a total of 196,906 renewals a year is necessary. On the basis of the average for all plants reporting, lamps are replaced about 1.6 times a year. The size of lamps used varies from 25 watt to 1,000 watt. Of 65 plants reporting a definite average size of lamps used, instead of the range of sizes, 61 specify a 100-watt lamp as their average size; 10 specify 75- and 200-watt lamps, respectively; 7 specify 50- and 60-watt lamps; 5 specify 150-watt; and 3, 300-watt lamps.

The total number of motor failures a year in the plants listed is 1,654; of the motors that fail, 1,029 or about 62 per cent have to be rewound. An analysis of the causes of these failures shows that worn bearings head the list; 15 plants give these as one of the chief causes of failure. In addition, other causes of failure for which the bearings can probably be considered as directly or indirectly responsible are listed as follows: bearing trouble, 3; oil-soaked insulation, 1; oil slinging, 2; oil, 4; oil on winding, 1. This makes a total of 26 instances in which bearings are a factor in causing motor failures.

Overloads come next, being listed 9 times; then in order come grounds, 6; moisture, 5; old age, and acid, 4 each; dirt, single-phasing, 3; insulation breakdown, old insulation, water and steam, iron dust, exposure (presumably to the weather), dust, careless operation, shorts, 2 each. The following causes of motor failure are each mentioned once: failure of overload relay, damaged insulation (cause not given), steel chips, poor ventilation, hard service, lightning, alkali, oil switch trouble, heat, tight belts.

The highest percentage of failures occurred in plant No. 20, a glass plant, wherein there are reported 215 failures out of 458 motors installed. Aside from several plants in which only a comparatively small number of motors are installed, and no failures have occurred for the past year or so, plant No. 77, making refrigerators, has the lowest percentage of failures: 1 failure out of 220 motors.

In the matter of facilities for repairing electrical and mechanical equipment, 54 plants, 67 per cent of the total, reported that they maintain repair shops for this purpose. Twenty-eight of these repair shops wind all or a considerable part of their own coils; two plants reported that they wind coils only in emergencies.

All but one of the plants listed conduct inspections of equipment on a definite schedule, the frequency of inspection varying according to the conditions. One plant reports that all inspections are made at varying intervals, with no set time for making them. Sixty-nine of the 80 plants employ one or more regular inspectors. A total of 193 inspectors are employed in these plants. In 32 plants motors are inspected once a day or oftener; weekly or oftener

in 32 plants, once a month or oftener in 12 plants and at varying intervals in the others. In practically all cases where inspection of motors is made on a definite schedule, motor control and protective devices, and material handling equipment is also inspected regularly, although in many plants the interval between inspections is longer than in the case of motors.

Thirty-three plants out of 72 reporting make a practice of overhauling their equipment at least once a year; 7 plants overhaul equipment twice a year, one plant overhauls equipment three times a year, and two do this four times a year. In plant No. 52 equipment is overhauled every Sunday. Twenty-five plants report that overhauling of equipment is done as needed, or when possible, as during slack periods, rather than on a definite schedule. In a few plants overhauling is carried on continuously, the repair gang going from one machine to the next in order. Three of the plants that overhaul their equipment twice yearly usually do so around the first of the year and in the summer; two plants find spring and fall more convenient for this work. Of the plants that overhaul equipment regularly once a year, five report that this is done during December or January, two do it during February and March, two in the spring, one in June, ten during the summer and two in the fall.

A study of the amounts of a few typical maintenance supplies used and carried in stock, and the stock-keeping practices of the plants reporting on these items, reveals some interesting figures. It will readily be seen from the table that in the case of wire, for example, three plants, Nos. 21, 47, and 73, appear to have on hand approximately a 3-yr. supply of wire; at the other extreme, plant No. 9 has only a 2-wk. supply on hand. Of the 41 plants reporting, 6 have from 2 wk. to 1 mo. supply of wire in stock; 6 have a 2-mo. supply; 16 have a 6-mo. supply; 5 have a year's supply; and 6 have over a year's supply. The total yearly consumption of these plants is 646,155 ft. of all sizes and 56,730 lb. of wire. Altogether, they have in stock 320,373 ft. and 8,200 lb. of wire.

In the case of carbon brushes, there is likewise considerable variation among the different plants in the relation between the yearly consumption of brushes and the amount kept in stock. At one extreme, plants Nos. 47 and 59 have a 5-yr. supply of brushes in stock; none of the plants has less than a 3-mo. supply. Of 35 plants reporting yearly consumption of brushes and brushes in stock in terms that are directly comparable, 4 have in stock a 3-mo. supply; 8 from 3 to 6 mo. supply; 8 from 6 mo. to 1 yr. supply; and 15 more than 1 yr. supply. Together these plants use 23,090 brushes and have 12,487 in stock, a general average of approximately 6 mo. supply.

Amounts of babbitt kept in stock range from 2 wk. supply, in one case, to a 5-yr. supply for one plant whose requirements are not very large. Out of 35 plants reporting yearly consumption and amount of babbitt in stock, 13 have on hand from 1 to 3 mo. supply; 8 have between 3 and 6 mo. supply; 6 have between 6 mo. and 1 yr. supply; and 7 have more than 1 yr. supply. The total consumption of these plants is 54,919 lb., and there are 13,522 lb. in stock, approximately 3 mo. supply.

The same general relations obtain between the yearly consumption of solder and the amounts in stock. One plant, No. 46, reports a consumption of 100 lb. per year, with 500 lb., 5 yr. supply, in stock. Plant No. 58, with a yearly consumption of 300 lb., has 10 lb. in stock, about 1 wk. supply. With 43 plants reporting, 22 have between 1 mo. and 3 mo. supply of solder in stock; 8 have between 3 mo. and 6 mo.; 8 have between 6 mo. and 1 yr.; and 5 have more than 1 yr. supply on hand. The total consumption of the plants reporting is 13,276 lb.; the total amount in stock is 3,388 lb., representing approximately 3 mo. supply.

Out of 44 plants reporting the yearly consumption and amount of tape in stock, 21 have on hand between 1 mo. and 3 mo. requirements; 16 have from 3 mo. to 6 mo. requirements; 3 have sufficient tape to last from 6 mo. to 1 yr.; and 4 have more than 1 yr. supply on hand. In some instances the consumption and amount of tape in stock is reported as number of rolls; the remainder of the plants report their requirements and amount kept in stock, in pounds. Assuming the weight of a roll of tape to be 8 oz. net, the total consumption of the plants reporting is 18,247 lb.; the amount of tape in stock is 3,536 lb., approximately 2½ mo. supply.

On the whole, the supply of lamps carried in stock, as compared with the yearly consumption, is somewhat smaller than in the case of the preceding items. Disregarding those cases in which plants did not report both their consumption and stock of lamps, or reported one or the other of these in terms of dollars spent, 40 plants reported consumption and number of lamps in stock. Of these plants, 11 have in stock 1 mo. or less supply of lamps; 16 have between 1 mo. and 3 mo. supply; 7 have between 3 mo. and 6 mo. supply; and 6 have between 6 mo. and 1 yr. supply. The total yearly consumption of the 40 plants is 142,571 lamps, while there are in stock 25,383 lamps. This represents a little more than 2 mo. supply.

Analysis of the delegation of responsibility for the selection and maintenance of the electrical and associated mechanical systems and equipment, as shown in the last few columns of the table, brings out some interesting facts.

Seventy-six plants reported as follows on the question of the title of the executive who carries the responsibility for maintenance of all electrical equipment: Chief Electrician, 45; Plant Engineer, 5; Electrical Engineer, Electrical Supt., Chief Engineer, 4 each; Engineer, Mechanical Engineer, 3 each; Electrician, Supt. of Maintenance, 2 each; Maintenance Engineer, Plant Electrician, Works Engineer, 1 each; Master Mechanic and Chief Engineer, jointly, 1.

Out of 76 plants the Chief Electrician or other individual who is responsible for the maintenance of electrical equipment reports to the Superintendent in 29 instances. In the remaining 47 plants he reports as follows: to Manager, 9; to Master Mechanic, 7; to General Manager, 6; to Chief Engineer, 5; to President, Vice-President, General Superintendent, Plant Engineer, 4 each; to Works Manager, Equipment Engineer, Electrical Engineer, Engineering Dept., 1 each.

In thirty plants, out of 70 reporting, responsibility for the maintenance of mechanical power drive equipment is borne by the Master Mechanic. In the remaining plants the Millwright bears this responsibility in 6 instances; Chief Engineer and Plant Engineer, 4 each; Maintenance Engineer, Engineer, Mechanical Engineer, 3 each; Chief Electrican, Foreman of Repairs, Supt. of Maintenance, Foreman, Superintendent, General Foreman, 2 each; Ass't Superintendent, Chief

Machinist, Works Engineer, Electrical Engineer, Mechanical Foreman, 1 each.

The individual responsible for maintenance of mechanical power drive equipment reports to the Superintendent in 35 of the 68 plants listed; to the Manager in 16; to Plant Engineer, Chief Engineer, 3 each; to Works Manager, Vice-President, 2 each; to President, Agent, Equipment Engineer, Engineering Dept., Works Engineer, Operating Foreman, Master Mechanic, Factory Superintendent, 1 each.

In 67 plants reporting, responsibility for maintenance of buildings is delegated as follows: Master Mechanic, 17; Superintendent, 12; Plant Engineer, 8; Chief Engineer, 6; Millwright, Construction Engineer, Mechanical Engineer, 3 each; Maintenance Engineer, Engineer, Supt. of Maintenance, 2 each; Property Manager, Steam Engineer, Works Engineer, Yard Manager, Supt. of Property, Engineering Department, Manager, Carpenter Foreman, Chief Carpenter, 1 each.

In 66 plants listed, these men report as follows: to Superintendent, 25; to Manager, 24; to President, 5; to Vice-President, 3; to Works Manager, Chief Engineer, 2 each; to Agent, Works Engineer, Engineering Dept., Equipment Engineer, General Superintendent, 1 each.

Responsibility for selection of size, type and make of electrical equipment used is delegated thus (78 plants reporting): Chief Electrician, 33; Chief Engineer, 7; Electrical Engineer, Plant Engineer, 5 each; Mechanical Engineer, 4; Electrical Superintendent, Engineer, 3 each; Superintendent, Works Engineer, 2 each; Manager, Plant Electrician, Engineering Dept., Supt. of Maintenance, Electrician, Master Mechanic, 1 each. One plant reports that electrical equipment is selected by conference, but did not give the titles of those who are called.

In addition to these, seven other plants report that electrical equipment is selected by the following individuals jointly: Master Mechanic and Superintendent; Superintendent, Chief Electrician and Master Mechanic; Chief Electrician and Engineer; Chief Electrician and Engineering Dept., Master Mechanic and Agent; Master Mechanic and Chief Engineer; Department Superintendents.

Seventy-three plants report that responsibility for selection of mechanical power drive equipment is delegated thus: Master Mechanic, 16; Chief Engineer, 11; Superintendent, 6; Plant Engineer, 5; Mechanical Engineer, 4; Chief Electrician, Engineer, Millwright, 3 each; Manager, Maintenance Engineer, Works Engineer, 2 each; Equipment Engineer, Electrical Engineer, Supt. of Maintenance, 1 each.

As in the case of the electrical equipment, mechanical power drive equipment is, in 14 plants, selected by two or more individuals jointly, as follows: Master Mechanic and Superintendent, 3; Plant Engineer and Master Mechanic, 2; Superintendent, Master Mechanic and Shift Foreman; Millwright and Foreman; Chief Engineer and Engineering Dept.; Conference (titles not given); Department Superintendents; Superintendent, Chief Electrician and Master Mechanic; Agent and Master Mechanic; Engineering Dept.; 1 each.

Selection of material handling equipment does not differ markedly in so far as delegation of responsibility is concerned, from the selection of mechanical power drive equipment. In 69 plants reporting, this responsibility is placed as follows: Superintendent, 12; Master Mechanic, Chief Engineer, Plant Engineer, 8 each; Mechanical Engineer, 4; Engineer, Works Engineer, 3 each; Manager, Chief Electrician, Maintenance Engineer, 2 each; Equipment Engineer, Supt. of Maintenance, Property Manager, 1 each.

As in the case of power drive equipment, responsibility for the selection of material handling equipment is divided in 17 plants. The groups that bear this responsibility and the number of times they were listed are: Master Mechanic and Superintendent, 3; Chief Electrician and Master Mechanic, 2; Chief Engineer and Superintendent; Chief Electrician, Millwright and Superintendent; Chief Electrician, Master Mechanic and Engineering Dept.; Plant Engineer and Master Mechanic; Electrical Superintendent and Chief Engineer; Conference (titles not given); Superintendent, Chief Electrician and Master Mechanic; Engineering Dept.; Chief Electrician and Millwright; Agent and Master Mechanic; Department Superintendents; Several Departments; 1 each.

Method of Making Tight Joints in High-Pressure Water Lines

SOME time ago the Bureau of Standards conducted tests on high-pressure hydraulic pipe lines, to determine the most suitable materials for wiping the pipe joints. These tests indicated that the most dependable material for pressures around 5,000 lb. per sq. in. was finely divided lead, mixed to a pasty mass with the usual litharge pipe dope.

Recently we installed a special, high-pressure fire system, involving a fairly high pressure of water, and due to the location of the installation, even the slightest leakage was not permissible. Brass pipe was used for this line, with the usual fittings, unions, and other connections.

In making up these pipe joints, the wrapped-thread method was tried first. This consists of wrapping a strand of packing cord around the threads, before screwing up the joint. The result was not satisfactory. The second method tried consisted in using lead in the pipe dope; this also failed, possibly because the lead was not ground fine enough, or because the dope did not have time to set. Knowing the usual trouble incident to making up brass pipe connections, it was decided to tin all joints by applying a thin coating of tin on the threads of the pipe and the connection.

One of the first and most important steps in tinning pipe threads is to see that they are as clean as possible. It is also essential to heat the pipe threads (one of the best methods is to hold them in the molten tin), before applying a good flux, and to have the molten metal clean and hot enough.

Wherever a tinned connection was screwed up and showed evidence of leakage, the torch was applied and it was sweated together. This method was not adopted without much lost time and considerable expense. Under similar circumstances, when brass pipe is used, we intend to save the cost of experimenting by using this method altogether.

The writer would like to know if anyone else has found a different method of equal simplicity for making joints in brass pipe absolutely free of leakage, while the pipe line is maintained under constant pressure, at all times.

Washington, D. C. G. A. LUERS.

MASTER MECHANICS of large industrial works have, probably, more miscellaneous and varied duties and responsibilities than any other plant men. The large area which they serve helps to make their problems more complicated, by increasing the difficulty of keeping in close contact with the men working under them. In this article, Mr. Slivinski tells about his work as Master Mechanic of Deering Works, International Harvester Co.

Some of the

Mechanical Maintenance Policies and Practices

which are used to keep an old plant and its power transmission equipment operating at high efficiency with low upkeep

By HUGO R. SLIVINSKI

Master Mechanic, Deering Works, International Harvester Company, Chicago, Ill.

In this section of the repair shop leather belts are cleaned, overhauled, recemented, put in good condition and placed in stock.

IT IS only through careful attention to the little details that maintenance work can be placed on a dependable and substantial basis. It might be possible to take a new, well-constructed, and properly-planned industrial plant and keep it in first-class operating condition at a comparatively low expense and with a correspondingly small amount of trouble. The problems connected with bringing an old plant up to good operating condition and keeping it there are much more numerous and complicated and can be solved only by careful planning over a number of years.

The maintenance cost and much of the trouble which usually goes with it can, by careful forethought, planning and attention to details, be brought down, even in an old plant, to a figure which the man in charge can be proud of. This, of course, requires time as the conditions would seldom permit a complete change or revamping of the entire plant at one time.

In this, it is extremely important to understand what are the causes of the troubles of operation and how they may be eliminated. I have had ample opportunity to try out some of my ideas in the plant with which I have been connected for the past ten years. Portions of this plant are about 40 years old and cover several acres. The principal product is farm machinery. The types of manufacturing include woodworking, a variety of metalworking processes, a foundry, and other special related work.

The principles which I have adopted for planning improvements of conditions and carrying on operations may be of value to other readers of INDUSTRIAL ENGINEER who may be faced with similar problems.

The work of the Master Mechanic of the average industrial plant is probably broader and more inclusive than the activities of any other plant executive. His work usually includes repairs to both machinery and buildings, general maintenance work, construction work, particularly if it is not extensive, erecting of machinery and auxiliary equipment, dismantling, moving and re-erecting machinery, a general supervision over most of the mechanical and sometimes electrical work, and over practically all tradesmen, such as carpenters, millwrights, and so on, except those directly connected with production. In addition, the Master Mechanic is generally expected to be the inventive genius of the plant, and develop new devices, machinery and, frequently, improve methods of performing particular operations or processes.

In that the Master Mechanic in his work travels from one end of the plant to the other and must study the related details of the manufacturing operations, he has an excellent opportunity to investigate

and suggest many methods of reducing the cost of manufacture. This is especially true along the lines of safety and material handling. He usually looks after the design, installation and improvement of safeguards. The fact that he can watch the operation of the various departments without being drawn into the detail and routine of them, gives him a perspective on much of the work which enables him to formulate ideas on material handling and devices and equipment which help to reduce the man-power required.

In addition to these, practically every plant has a multitude of miscellaneous duties, many of which are placed in charge of the Master Mechanic, often because there appears to be no other place to put them. Among these duties are janitor work, and frequently some special duties incidental to his particular plant. This article takes up some of the points affecting his activities, particularly as they apply to maintenance work.

The problems in connection with the maintenance of the power transmission equipment, both mechanical and electrical, are perhaps of most importance in that continuous operation of the plant is entirely dependent upon their functioning.

For most kinds of manufacture, I am in favor of group drives. Also, I am partial to leather belts. Approximately 90 per cent of the machines in the plant with which I am connected are belt-driven. Leather belts are used in practically all cases except on screw machines where they would soon become soaked with oil, and in some departments where the heat is too severe. For these, we use specially-treated, fabric-base belts.

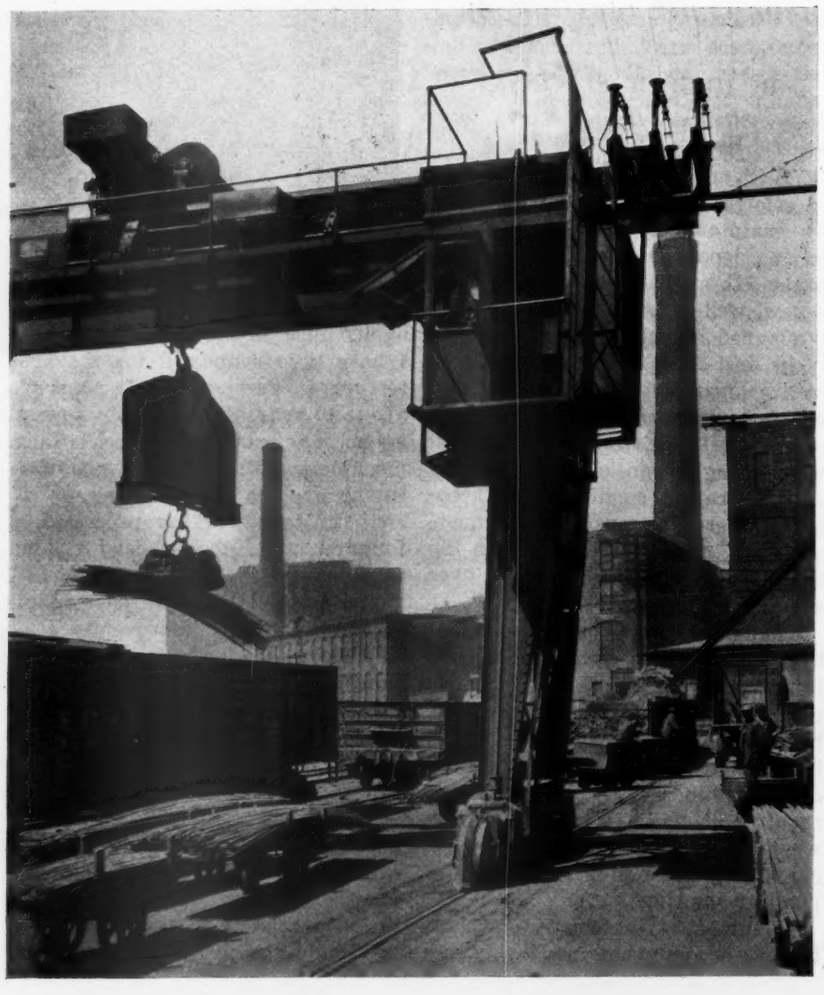
Each department has a combination belt man and oiler who tightens all the belts in the department and oils the lineshafting, but not the motors. On the smaller belts, up to 6 in. wide, a special wire belt lacing with rawhide or Bakelite hinge pins is used. This is not only easy to apply, but is lasting. The belt man takes the lacing machine directly to the job and the idle machine is operating again within a few minutes.

On fabric-base belts I prefer plates and rivets, for the larger sizes, and for belts under 6 in. wide, a special curved plate with projecting teeth which are driven through the belt and the ends clinched, is used. Leather belts over 6 in. wide are cemented endless. The problem of losing belts has been overcome by requiring that an old belt be turned in before a new one is issued. In this way, the belt loss in the plant is negligible.

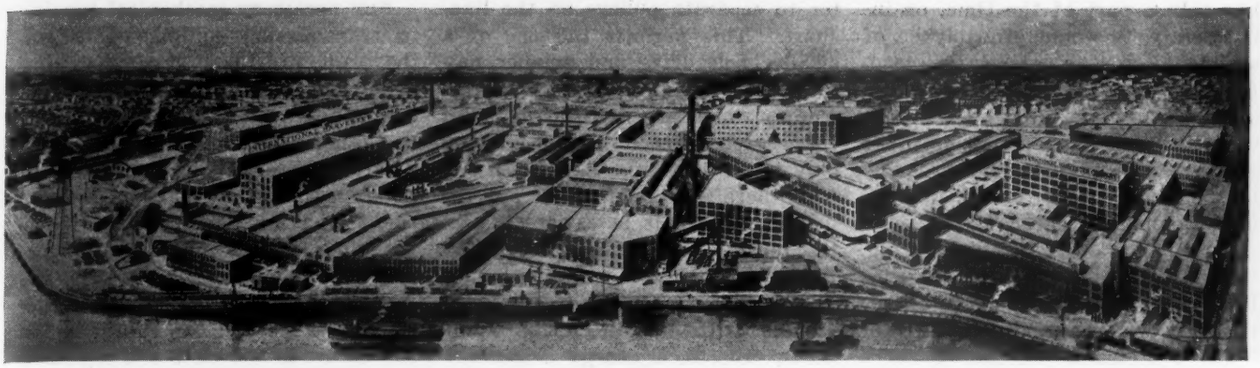
In addition, old belts after they have been removed are cleaned by soaking them in benzine and then scraping and rubbing the grease out of them, loose plies re-cemented, short pieces built into longer belts by cementing together, trimming the edges where necessary, and finally re-oiling the belt so that it is ready to be used again. These rebuilt belts are put in rolls in stock to be issued out as necessary. In addition, we are gradually using up an old 52-in., three-ply belt taken from an engine drive operating the woodworking department. Pieces are cut off this as needed. On belts 6 in. wide and larger, the worn ply is left on. For smaller belts, the worn ply is removed, which leaves a two-ply belt. The leather in this old belt is in very good shape although it had been used for years. The smaller belts which are cut from it will probably have an equal life in the plant. These belts are oiled and dressed if necessary before putting into use. This source of supply is responsible for a very low belt cost. Belt records are not kept although at one time they were used. When the best method of treating and handling belts was found, this record and its expense was eliminated.

The next important part of a power drive installation is the lineshaft. In lineshaft work, it is well to standardize on speed, diameter of shaft, and type of construction to support shafting, bearings, and hangers. All lineshafts operate at 200 r.p.m., except in the woodworking department, where they operate at 250 r.p.m. An exception also is made in the lineshaft driving the tumbling barrels.

Under former conditions lineshaft bearings had been a source of considerable trouble. It was finally decided to standardize on roller bearings and they were tried out on one



This special gantry crane was installed to unload incoming steel.
The steel is lifted from the cars by a magnet and the weight taken by the special scale. These trailers are hauled away by tractors. This installation in its first year more than saved its cost by decreasing the number of men required.



The extent of the Deering Works is shown in this view.

This is one of the principal factories of the International Harvester Company, in Chicago. The large area which must be covered is one of the problems which faces the Master Mechanic in his activities. As is often the case, this plant has repeatedly been enlarged with the result that some of the buildings are quite old while others are modern.

shaft. Since that time whenever a lineshaft is taken down for any cause or is overhauled extensively, standard roller bearings have been inserted in place of the former bearings. At present, practically the entire plant operates on roller bearings. This has brought lineshaft troubles down to almost nothing. Occasionally, when it is necessary to add a night force and so put on new oilers we have had a little trouble. This has never been serious, at least compared with the former condition.

It is well to standardize on the size of shafts and in the method of erecting them. It is frequently necessary to move or change a lineshaft. With standard dimensions of units or methods of supporting, this interchange is much more easily made. Compression couplings also make it easier to change a lineshaft. With compression couplings it is possible to use solid pulleys and, if desired, solid instead of split bearings. Also, when the couplings are taken off, the shaft can be stored more easily or handled with less likelihood of springing, than if flanged.

A standardized method of supporting lineshafts has many obvious advantages. Primarily, the men always know how the job is to be done. Practically all of the buildings are of mill construction which makes it much easier to standardize on the method of supporting the shaft than if varying types of construction had been used. This construction consists of longitudinal pairs of angle irons which form rails and are placed close together with sufficient space between each pair for the bolts which attach the feet of the hangers. The pairs of angle irons are in turn supported on cross angles which are fastened with bolts or lagscrews to the ceiling timbers. A long lagscrew extends from this cross angle to the ceiling from midway between the pair of longitudinal rails and provides additional support.

The feet of the hangers are planed, which gives a firm footing and permits them to fit tightly and evenly against the angle-iron rail support. With this construction a hanger can be shifted a few inches or a foot to take care of placing any pulley, or this construction can be taken down and moved to a new location along with the shaft. I also favor drop-end hangers as then the shaft can be put together on the floor and lifted up into position or let down and dismantled as desired.

Tumbling-barrel drives are bothersome problems in connection with most foundry work. In one case we were faced with the problem of installing a number of tumbling barrels in a very compact space which necessitated running the shaft underneath the barrels. The tumbling barrel rests on each end on a pulley on the lineshaft and an accompanying idler pulley. Both pulleys are of the same diameter and the shafts for the two are placed a short distance apart and at the same level. The ends of the barrel rest on and between the two pulleys. The weight of the tumbling barrel holds it down on these pulleys and the rotating lineshaft pulley revolves the barrel. The shaft is revolving all the time at a speed which drives the tumbling barrels at 200 ft. per min. To stop and empty or fill any barrel, a third pair of pulleys is forced against the tumbling barrel which lifts it free from the lineshaft. This drive has given no trouble and has now been in use a number of years. Roller bearings are used here, the same as on other lineshafts.

I have been a firm believer in locating the sources of trouble in the plant and, whenever possible, substituting something else for the equipment which causes the trouble. As an example of this, clutches were located on the lineshaft to connect up a number of machines. As these were not operated regularly and continuously as on a press, we made a change and used a countershaft with a shifting belt and loose pulley. This increased the length of belt and added a countershaft, the cost of which would have been counterbalanced by a new clutch. However, as all maintenance work on a clutch when it is so located must be put in after hours so as not to stop the lineshaft, we felt that a beneficial change had been made.

On machines which must be thrown in and out quickly, as presses, gears, and similar equipment, where a clutch is required because the belt shifter would be too slow, I have found it more advisable to put the clutch directly on the machine. In this way, whenever any maintenance work is necessary on the clutch, the belt can be thrown off the pulley, the adjustment made, and the machine be operating again in a short time.

Another substitution which reduced the operating as well as the maintenance cost considerably was to replace a train of gears with a worm-gear reduction unit. This not only gave a much more compact arrangement but reduced the number of working parts and increased the ease with which it could be oiled and cared for.

While on the subject of trouble-making equipment it may be well to emphasize a point which is too often neglected in the selection of various types of mechanical power drive equipment. Altogether too often such equipment is purchased on entirely too close a rating. Suppose that the ordinary amount of power transmitted by a piece of equipment is 2 hp. If this equipment is operat-

ing only a part of the time, or infrequently, it would probably be of sufficient size to carry the load. However, if it is operated continuously, as would likely be the case with a clutch on a punch or other similar tool, 2 hp. would probably be too low a rating for the job, unless the manufacturer had made a special allowance in his rating. Ordinarily, this is not the case as the rating is usually made on ordinary work. Every piece of power drive equipment, whether it is a clutch, coupling, variable-speed drive, belt, or other device, should be of sufficient rating or rather sufficiently overrated to stand any service which may be placed upon it. This extra allowance alone has much more than paid its increased first cost by decreased maintenance.

It is an expensive policy to keep large stocks of surplus pulleys, shafting and other supplies on hand. Whenever any new construction is planned any materials available are first taken from stock and any more which may be required, are ordered. For the whole plant there are only six spare roller bearings for any replacements which might be necessary in any of the lineshaft hanger bearings in the plant. Perhaps this would not be possible for plants which are not located so close to jobbers and supply houses as are plants in Chicago.

Another device for facilitating millwright work is a special platform which can be moved from place to place and erected under the lineshaft, straddling machinery if necessary, to provide a safe and convenient place for the workmen to stand, with some space for them to move about. If the ceilings in the building are practically all of one height the legs may be made solid and not with extensions. The platform shown in an accompanying illustration serves the purpose quite well. This has a chain railing and a platform made of five pieces including the toe-boards. The toe-boards are fastened on by hinges and may be folded back for ease in transporting. The pipes at the corners which support the chain railing, may be lowered to make the entire unit more compact and enable it to pass through doorways more easily.

Practically all large motors driving the various lineshafts in the production department are provided with an extended shaft with pulleys on each end. In this way, belts are connected from each end of the motor to separate pulleys on the lineshaft. This permits the use of a smaller belt drive and smaller pulleys. For example, on the 75-hp. motors which are used on many of these groups, each belt is driving only about 37½ hp. Also, with two belts there is no tendency to pull the motor askew. It is easier to keep the tension and causes less trouble than if a single belt were used.

We have comparatively little trouble with our electrical equipment. Electrical energy is generated at 550 volts, three-phase, 40 cycles. Induction motors are used on most all of the drives; a few variable-speed motors are supplied with direct current from a separate generator.

One man oils and inspects all of the 900 motors in the plant. In addition, the foreman of each department is supposed to watch for any exceptional heating of the motor and report it. Practically all motors are mounted on the ceiling or where they are out of the way from all damage, except by neglect.

The question of whether a plant should make its own motor repairs is open to discussion. In a large city where there are a number of companies which make a specialty of this work, it is generally advisable to send the motors out for any rewinding or extensive repairing. Bearings should, of course, be changed in the regular repair shop. If a company has a large amount of motor repair work, it may then be advisable to do its own repairing. However, investigations should first be made to determine *why* a large amount of repairing is necessary. Where outside facilities for quick repairs are not available, it would probably be wise to make provision for doing this in the plant. With an average of only about one motor to repair a year (exclusive of bearing troubles), we send this work outside. Miscellaneous electrical repair work is done within the plant.

When a Master Mechanic has the repair and rebuilding of all production machinery, together with the design and building of many new special machines, his machine shop is probably one of the largest divisions of his department. The machine shop under my supervision includes a large variety of machine tools capable of handling almost any type of work. All standard machine tools are purchased for production processes but some machines are designed and built for special work.

Any necessary mechanical repairs to transmission equipment, or for the plant, are taken care of in this department. Similarly, there are special carpenter and paint shops and other departments which devote a large proportion of their time to making equipment or supplies for the production departments and at the same time taking care of necessary maintenance activities. The extent and functions of these departments depend, of course, upon the nature of the work and the other facilities within the plant, as well as upon the policy of the company in this respect.

With machinery, the same as with lineshafting, it is false economy to attempt to use any but the best bearing material. For example, on high-speed, medium-pressure bearings, a copper-base, high-grade babbitt is used. Lower grade babbitts are used on low-pressure, slow-speed bearings. Bronze bushings are usually used on rolls and on punch presses where the bearing pressures are high. Each machine is oiled by the operator.

Whenever a machine is taken down and repaired or overhauled, it is always given a coat of paint. This freshens up the machine and the operator looks on it more as he would a new machine and so gives it better treatment.

While many Master Mechanics want to do all of any extensive construction work incidental to the installation of new equipment and sometimes additions to buildings, I much prefer to have as much of this as possible done by outside concerns on contract. They have better facilities for doing this kind of work and generally the industrial plant man has enough to do with his own work and the necessary inspection and supervision over a firm doing the work on contract, without taking on the heavy duties which would naturally be a part of his trying to do the work himself. On small jobs it is, of course, generally easier and cheaper to do them yourself than to bring in someone from the outside.

Repairs to the buildings, floors and yards, are, of course, a part of the Master Mechanic's activities. A wood floor laid on stringers has many advantages and is my preference, except in foundries, around furnaces and ovens, presses, and similar locations, where it would be impracticable. While it is easier to truck where the flooring is laid diagonally, such floors are very dif-

ficult to repair. Floors laid straight with aisles are easier to repair.

As already stated, safeguards are commonly designed and installed by the Master Mechanic's department. This calls for close co-operation with the Safety Department so as to find out where safeguards are needed and what types of accidents need to be guarded against. A safeguard to be effective should be substantial, neat in appearance and easily removed or replaced, if necessary, to permit adjustment of the machinery. The safeguards, on the other hand, should not interfere with production or operation but still effectively guard the machine or tool so that it is almost impossible for a man to injure himself.

Sometimes these guards are simple and at other times more complicated. For example, in one case a guard was installed which requires the simultaneous action of one foot of the operator as well as both hands of the operator and of his helper. In another case, on a straightening hammer, a sweep was designed to operate by a projecting arm fastened to the die head and sliding in a spiral groove which passes the sweep across the face of the die block in such a manner as to knock a hand out of the way ahead of the hammer. Similarly, guards which protect the hands of truckers have eliminated many of those minor accidents which frequently become infected.

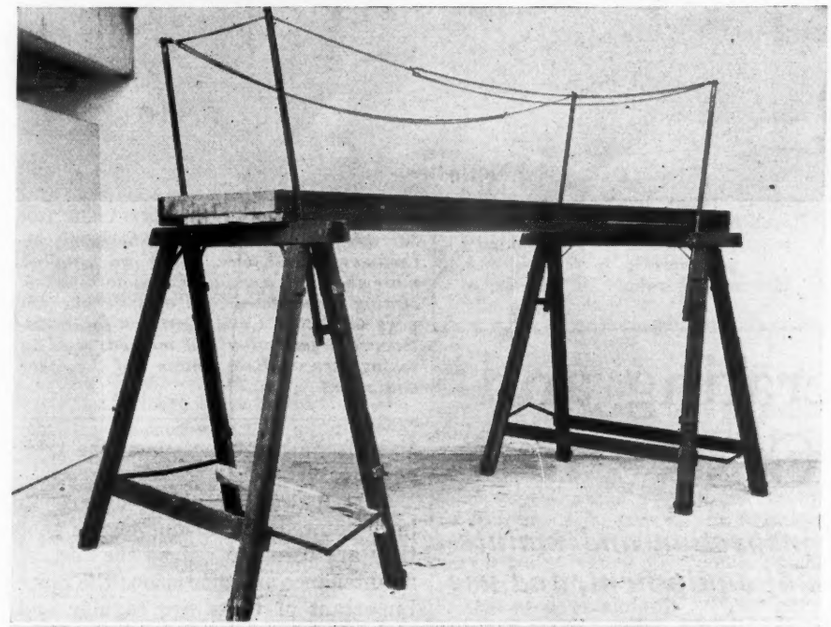
In some cases, it is possible to simplify the operation of a machine and at the same time as it is being guarded. For example, in one case on a large shear the foot treadle which threw in the clutch was difficult for the man to operate in that he had to put his entire weight on it to trip the clutch. An air cylinder was connected in to trip the clutch, with the valve operated by the foot treadle. Extra guards were placed so that the treadle could not be tripped accidentally, and, could be operated from only one position in front of the shear. This made it much easier to operate the clutch, eliminated fatigue, and so increased production.

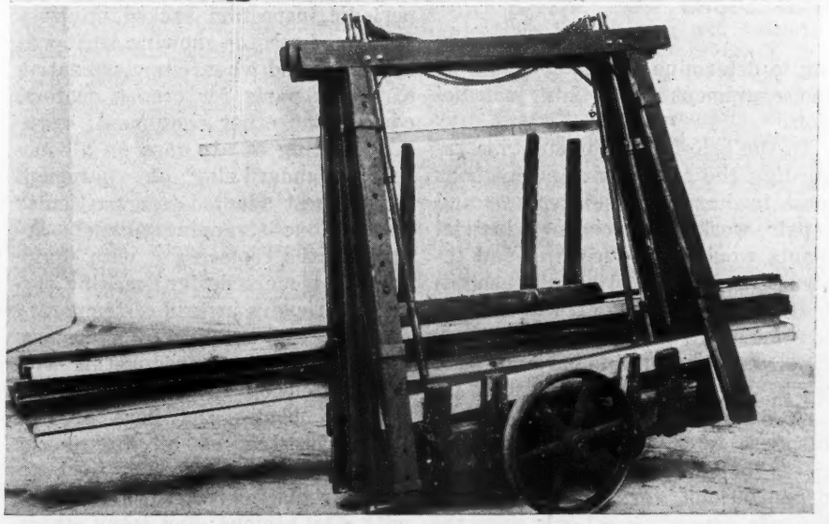
Material handling offers many opportunities for the man with some inventive genius, and not so closely involved in the work as to narrow his viewpoint, to suggest or design numerous improvements. One instance is connected with the installation of a gantry crane mounted to run on tracks on the outside of two lines of switch track, as shown in the accompanying illustration. This is used either with a magnet or with a hook and sling to unload all steel as received and to load scrap and steel shavings on the car for shipment. The first year this crane was put in, it saved the labor of 36 men daily for a year and more than paid for itself.

The idea for this was worked out roughly and turned in, together with the estimated cost and possible saving, as a suggestion, before the management made any real suggestions for research along that line. If there is any way in which a Master Mechanic or any other industrial executive, can add to the importance of his position, it is by anticipating needs and requirements before anyone else and offering a solution for them. It may frequently happen that his suggestion is not appreciated at the time, but if he is a careful student of his problem and has faith in his idea, all he has to do is to wait and when the right situation arises he will be ready to bring out his idea again and stand a very good show of its being accepted.

In addition to the larger things which require submission to the management before they are carried through, there are any number of little things which come in as a part of the work and can be put into effect at any time.

A special millwrights' scaffold or platform is used on overhead work. The upper illustration shows how the scaffold appears when it is erected. The lower illustration shows how it is knocked down and packed on a truck to be taken from one department to another. Standardized equipment, such as this, facilitates maintenance work; this scaffold can be adapted for practically any job and is easily erected and transported. The platform is made of five boards, with the toe-board hinged on the edge of the outside board. The safety chain and toe-board are easily installed safety features.





In this sawmill of the Shevlin-Hixon Company, Bend, Ore., there are installed more than 200 a.c. and d.c. motors, representing a connected load of 3,000 kw. On page 68 W. B. Cone describes the maintenance organization and methods used in taking care of these motors and the other equipment.

How some industrial plants are

Reducing Operating and Maintenance Costs

by efficient organization of inspection and maintenance work, standardization of equipment, and use of modern testing and repair devices

THE primary function of the maintenance engineer is to keep the plant running. To keep an industrial plant in efficient operating condition at all times requires a well-organized group of men who are trained along definite lines, together with a system of periodic and thorough inspection, backed up by facilities to make any immediate repairs that may be required. With such a background as this, the man in charge of operation and maintenance soon sees ways of reducing operating costs by rearrangement or use of improved equipment, by better methods or better equipment for making repairs, and by careful testing to determine the exact status of the equipment under his jurisdiction.

In the belief that some details regarding the equipment and methods used in handling maintenance and repair work in various industrial plants would be interesting and instructive, the questionnaire shown in the accompanying box was sent to some of the readers of INDUSTRIAL ENGINEER who are in charge of such work.

A study of the letters received in response to this questionnaire discloses that there are various types of organizations for handling maintenance, depending not only upon the size of the plant, but upon the type of industry served.

Contributors to this discussion have pointed out various means that they are using to reduce the cost of maintenance and operation; the more important of these are regular and periodic inspection backed up by a system of records showing what was inspected and when; standardization of repair parts for cranes, motors, control and other equipment; regular checking of air gaps on all motors; standardizing on equipment that is best adapted to a particular application; scrapping obsolete apparatus and replacing it with equipment of modern design; making permanent repairs instead of temporary ones; careful refilling of all renewable fuses by one man, together with more attention to the contact surfaces of blades and jaws of fuse clips; filtering of oil to remove foreign matter injurious to bearings; replacing cast-iron pinions with steel pinions; and many others.

Trouble of a mechanical as well as electrical nature is encountered with equipment. This is, in the main, due to severe operating conditions, such as overloading, improper starting, acid fumes, carbon, dirt, and water as well as poor installation, and lack of proper maintenance.

Use of improved equipment has resulted in a marked saving in a large number of cases. Among those mentioned are the use of sealed sleeve, and ball and roller bearings for motors and other drives; wider use of automatic control, thereby reducing the number of operators required and also reducing the starting duty on motors; use of overload relays, in particular, the thermal overload relay; use of speed reducers in dirty locations, thereby greatly reducing the maintenance required by the equipment replaced; use of flexible couplings and direct connection in preference to other forms of drive; changing from belts to silent chain drives in some instances; use of synchronous motors for power factor improvement; and so on.

The discussions disclose a wide use of portable indicating voltmeters, ammeters and wattmeters for checking and testing the condition of various types of electrical equipment. Particular attention is called to the value of graphic wattmeters and tachometers, as well as devices for measuring insulation resistance.

In the repair shop, too, many improvements have been made that are resulting in economies. Among those items of equipment that are mentioned as being of particular value are, baking ovens; an improved type of gasoline spray for cleaning; paint or varnish spray guns; portable air compressor for blowing out and cleaning equipment, oxy-acetylene cutting and welding equipment; arc welding outfits; and many others.

The letters giving the details of the economies and methods mentioned are quoted below:

* * * *

J. S. Murray, Chief Electrician, Follansbee Bros. Co., Toronto, O. *Question 1.*—Our plant is devoted to the manufacture of high-grade automobile sheets, from the raw material to the finished product. All our equipment is completely electrified. We generate all of our power, having a consumption of about one and one-half million kilowatt-hours per month. We have about 600 motors totaling around 15,000 hp., and station capacity of 7,500 kw. Our Electric Department employs 94 men, and is divided into the following divisions: Inspection, Repair Shop, Construction, Sub-Station, Meters, Crane Operators and Coal Mine department.

For taking care of inspection, plant equipment is divided into three sections with an inspector and two helpers in each of two sections on 8-hr. shifts, seven days a week. The remaining section has one inspector on a 10-hr. day turn, seven days a week.

At the end of each turn each inspector makes out a report, shown in an accompanying illustration, which is sent to my office. The inspectors are responsible for the condition of all electrical equipment in their section, on motors up to and including the motor pinion, as well as all electrical and mechanical work on traveling cranes. Each inspector has a third portion of the equipment in each of the first two sections which he is responsible for from a maintenance standpoint, but he is always available in the entire section in case of a breakdown. These same inspectors also make the cranemen responsible for cleaning and lubricating certain parts of the cranes.

The Inspection Division is not expected to do repair work, except of a minor character, on spare parts. Spare parts for both mechanical and electrical equipment are located at central points. The inspector's report form shown on page 69 tells what has been used each day and provisions are made immediately to replace the part.

Our electric repair shop is located in a central portion of the plant and is equipped to handle all electrical and mechanical maintenance in the Electrical Department. We have a shop foreman, armature winder, machinist and repair electrician employed here; also we have floor space for two electrical millwrights who work there at times in carrying on millwright work in the department in connection with bearing re-babbitting, machining fits, and similar mechanical operations.

The millwright, inspection and repair shop forces are very closely in touch with each other at all times with respect to the condition and location of required spare parts.

We maintain a Construction Division for the purpose of installing all new work and making changes or improvements when desirable.

We have operators in a central substation, shown in the illustration on page 71, which contains our blooming mill drive, our step-down transformer equipment, motor-generator sets and air compressor drives. All power house feeders enter this building except two feeders to our hot mill roll drives. Therefore, all low-voltage feeders, both a.c. and d.c., leave this substation and are under the care of these operators.

We employ a meter man to maintain our meters properly and make the proper distribution of power charges each month. This man also maintains a close check on pyrometer equipment at the annealing furnaces and checks overload relay settings on the important units. He also takes care of any drafting that may be required, and keeps a check on the insulation resistance of the more important units.

We have about 56 cranemen who are hired and trained by the Electrical Department. All cranemen are subject to the orders of the Electrical Department with respect to the proper handling of crane equipment. This system is very successful.

Complete data on all electrical and mechanical equipment are filed in the Chief Electrician's office, and cross-indexed by a clerk. This clerk also balances daily his disbursements against his storeroom inventory, on both electrical and mechanical spare parts, so that the possibility of overlooking parts used is very remote. We maintain our own storeroom, for important parts, adjacent to the electric shop, and stock detail parts in the regular mill storeroom.

We have our own coal mine with a mine electrician in charge. A motor-generator set is located in the center of the coal field, with a bore hole for direct-current cables leading to the mine for mining machines and locomotives. The maintenance of all equipment in the mine is done at the mill repair shop.

Question 2.—We believe that standardization has saved us more than any other one thing. We have found it possible to limit the sizes of track wheels for the various bridge and trolley wheels on 26 traveling cranes. No effort was made originally to standardize rail sizes or wheel diameters; it was accomplished by consideration of various axle diameters and hub lengths. Very close checks are maintained on motor and control parts, so as to keep down the variety of parts required. We have also made considerable saving through the standardization of gears, brake wheels, shoes, bushings, etc.

Question 3.—We have had trouble with some of our flexible couplings, due to severe service in some cases and lack of proper attention in others. We have corrected this by installing improved types of couplings in some instances and devoting more attention to inspec-

Questions Asked Readers of Industrial Engineer

(1) Tell us about your organization and methods of handling maintenance and repair work.

(2) How and where have you made the largest savings in operating, maintenance and repair costs?

(3) What piece of equipment, either electrical or mechanical, gives you the most trouble? In what way? Why?

(4) What changes or additions have been made in the past two years to electrical or mechanical power drive or material handling equipment that have improved operating conditions, or cut maintenance and operating costs?

(5) What kinds of testing equipment do you use and what have you found most valuable in the inspection of plant equipment?

(6) What equipment do you use in your repair shop? What piece or pieces of equipment have enabled you to make the largest savings in cost of repairing electrical and mechanical equipment?

tion and maintenance of the couplings in others. We have also had considerable trouble with mechanical parts on forging manipulator cranes which are used in forging ingots under a steam press. These troubles are being overcome by changes of design and using better material in parts showing the greatest abuse.

Question 4.—The most outstanding saving made in the past two years has been brought about by the adoption of sealed-sleeve type bearings on our general-purpose motors. This type of bearing has reduced our rewinding cost by 40 per cent. Several other changes have helped to lower costs, such as a more liberal use of automatic control at our coal mine, substation, and on hot and cold roll drives.

Question 5.—For testing we use a graphic wattmeter; Weston indicating voltmeter and ammeter; Weston shunts, 25- to 800-amp. capacity; Esterline shunts in 25 to 400 amp. sizes; Westinghouse a.c. voltmeter and ammeter; Esterline "Utility" current transformers, 25- to 800-amp. capacity; Weston millivoltmeter, 0 to 300 volts; Brown Heatmeter, 0 to 2,000 deg.; Biddle Bridge Megger; Jagabi speed indicator; stop watch; potential transformers, 20/1 and 2/1; potentiometer, 75 to 2,000 deg.; Westinghouse portable standard watt-hour meter. We find the graphic wattmeter, Biddle Megger, and the Heatmeter are of much value in performing the work outlined by the meter division.

Question 6.—In our electric repair shop we use a 30-in. American lathe, shaper, drill press, large wheel press, armature banding machine, varnish dipping vats and baking oven. We believe that from a mechanical standpoint the shaper, lathe and wheel press make the greatest savings. From the electrical standpoint, the baking equipment permits greater savings on winding costs. However, we consider all of the equipment indispensable to us because of the large amount of mechanical equipment which we maintain.

* * * *

W. B. Cone, Chief Electrician, Shevlin-Hixon Co., Bend, Ore. *Question 1.*—The Shevlin-Hixon Co., a manufacturer of white pine lumber and lumber products, is located in one of the largest white pine belts in the country. The scope of operations not only includes regular saw mill operation and manufacture of some finished products, such as boxes, etc., in the plant illustrated on page 66, but also logging and transportation of the logs to the mill.

In the saw mill at Bend, Ore., there are over 200 motors requiring both alternating and direct current and drawing an average load of 3,000 kw. from our own power plant. Besides operating and maintaining the power house and motor drives throughout the plant, the Electrical Department takes care of a fleet of storage battery industrial tractors.

Our electrical maintenance crew consists of five men, which is an unusually small number for a plant of this size. Each man has a great deal to do, but due to the definite assignment of responsibility, we are getting very good results. When much construction work is to be done, more men are added.

Question 2.—If there is any place that the "ounce of prevention" proverb applies it is in the maintenance of electrical equipment. All control equipment is gone over once a month and carefully inspected for signs of overload or trouble. Motors are given a similar overhauling and all worn parts are renewed or repaired. In addition to this thorough overhauling, daily inspection is given the equipment by the maintenance men assigned to the various departments, and who are held responsible for the equipment.

Questions 3 and 4.—Fan motors are very important machines to keep running in a lumber mill, and inasmuch as they are mounted overhead so as to make room for the sawdust pipes, they are difficult to inspect. Besides the usual forms of motor protection, we are now using a thermal overload relay which is mounted directly on the stator laminations of these fan motors. These relays are arranged to open the circuit on the low-voltage release of the compensator and stop the motor, whenever its temperature reaches 65 deg. C. These thermal relays keep close watch of the motor temperature and danger of single-phasing, with resultant burnouts, has been eliminated.

Question 5.—Our testing equipment consists of indicating voltmeters and ammeters for both alternating- and direct-current service, wattmeter, magneto, and an insulation resistance measuring set with a range of 100 megohms. This latter instrument is indispensable for testing purposes. We also have a millivoltmeter for testing d.c. armatures.

Question 6.—We do all our repair work in our own shop. In this shop we rewind our motors and dip and bake the smaller ones in a small baking oven. The larger motors are dipped and baked in one of the kilns used for drying lumber. We make our own coils for motors below 10 hp. rating, but carry a complete stock of coils for the larger motors. In this same shop, brass and bronze bearings are bored and machined to size and steel-clad bearings are rebabbitted. Adjoining the repair shop is a storeroom with complete line of spare parts and supplies for the Electrical Department. This material is specified and ordered through the Purchasing Department by the Chief Electrician.

* * * *

Lee F. Dann, Chief Electrician, Donnacona Paper Co., Donnacona, Que., Can. *Question 1.*—In our plant we have approximately 175 motors ranging in sizes from 1 to 1,500 hp. There are five 1,500-hp. synchronous motors and two 1,200-hp., wound-rotor, induction motors. These machines are inspected weekly, blown out with compressed air and thoroughly wiped off. The air gaps on the motors are checked once a month and if any variations are shown immediate adjustments are made. In addition the insulation is given a Megger test once a month.

The remainder of the motors are well distributed in every section and corner of the plant and yard on all kinds of drives, and subjected to all kinds of acid fumes, temperatures, dust, and moisture.

One man makes two daily inspections of all these motors, looking after the oiling, cleaning and any other points that require attention. From 75 to 90 per cent of all paper mill motors operate continuously 24 hr. a day, six days per week; therefore the motor inspector must not only watch the motor, starter and other electrical equipment in each particular case, but must also keep a lookout for mechanical troubles. Paper manufacture is a sequence of operations, one dependent on the other; therefore each motor must be ready at all times to do a full day's or a full week's work. Even a small motor burning out a bearing might cause an expensive shutdown and it pays to have a motor inspector who keeps a conscientious watch on everything.

In the electrical repair shop three men are employed, one on each shift of eight hours. These men handle all calls throughout the mill at any time and make the necessary repairs or adjustments to keep the apparatus running, unless a new bearing or a change of motors is required. In the latter cases they are assisted by both machinists and millwrights. In addition, these three men repair all machines brought into the electrical shop for extensive repairs. Practically all rewinding is done in the shop. This is necessary here as the nearest repair shop able to handle this kind of work is 150 miles away. Owing to the length of time required to obtain repair parts, a fairly large supply is kept constantly on hand, including coils, magnet wire, motor bearings, starter parts, relay parts and switch parts. These supplies are not in the regular storeroom, but are in the electrical shop where they can be had at a moment's notice. The repairmen are required to keep a close watch on supplies and immediately tell the man in charge of any needed material. Five other men are employed on new construction, changes and line work. The mill has considerable line work, as all feeder circuits are run on the roofs of the building open construction.

We have a system of weekly inspection, done every Sunday while the mill is closed down. Lists of apparatus have been made up and divided into what comprises a full day's work for the repairman and a helper drawn from the construction gang. It requires six weeks to cover the plant completely; thus each piece of apparatus is inspected at least eight times a year. A few pieces of equipment that see severe service and are very important are inspected weekly by the repairman in addition to his regular Sunday work. Lighting equipment is cleaned regularly by one of the younger helpers in the construction gang. A great many of the lamps are in hot places rather difficult of access and we find it more economical to have the work done when the mill is closed down on account of the tendency of the men to slight the work if done when the mill is running.

Form 28-E2C-11 28

FOLLANSBEE BROTHERS COMPANY, Toronto, Ohio

Date 12/1/25 Turn 7 30 A. M. to 12 30 P. M.

ELECTRIC DEPARTMENT MOTOR INSPECTOR'S REPORT ..... P. M. to ..... A. M.

Machine	Time Lost				Cause	How Repaired
	From	To	Hrs	Min.		
#19 Manipulator	10	10 22		30	Bridge Arm. Grounded	Changed armature
# 2 Ladle Crane	2	2 15		15	Broken trolley drive shaft on end hoist	Changed unit with gear and pinion

REMARKS: Performed general inspection of equipment in my section

Material Used	Department	Machine
1 - armature complete, spare #300 1 - trolley drive shaft complete with gear and pinion spare #10	Press Open Hearth	#19 Crane # 2 Ladle crane

Material Needed	Department	Machine
1 - spare armature 1 - spare shaft for trolley drive on #2 Crane	Press	#19 Crane

John Brown Motor Inspector

James Smith Shop Foreman

Oscar Wilson Gen. Foreman

A motor inspector's report, that is more than a list of equipment, which was supposedly inspected. This form is used at the Toronto plant of Follansbee Bros. Co.

Question 2.—A large saving in repair parts is due to our regular inspection system. Take, for example, 100 starting compensators; these require numerous contacts and small parts which are not very expensive so far as first cost is concerned, but can be made very expensive unless properly and completely used. All contacts removed from starters are sorted over in the shop; those that can be filed or ground so as to be used again are laid aside and put into working order by the repairmen in spare time. These second-hand parts are used only on the starting position of compensators, new contacts being used on the running side.

Question 3.—Motors, starters and associated mechanical equipment used in yard service cause the most trouble. These installations are more or less temporary, and as usual with jobs of this kind almost anything goes. Motors are never set level, thus causing bearings to heat through loss of oil and end thrust. The natural results of this are stators and rotors rubbing, causing windings to be damaged, and oftentimes burned out. The starters and relays are severely used, being moved from one location to another and often abused by the operators.

The next in order for serious trouble are a few motors under severe operating conditions such as pump and fan motors in the sulphite mill which are exposed to strong acid fumes. The windings of these machines are short-lived at the best, and in order to keep the insulation in operating condition the motors are brought into the shop two or three times a year and given a thorough drying and cleaning; afterwards a coat of acid-resisting, insulating varnish is applied with a spray gun. Varnish is applied at various pressures depending on the condition of the insulation. If the tape on the coils appears to be loose or rotten, only 15 or 25 lb. pressure is used; if tape appears to be in good condition more pressure is used.

Question 4.—The growing tendency to use ball or roller bearings and the trend towards the use of more direct-connected apparatus are important. Machines and motors are connected indirectly by the use of speed reducers, of which there are numerous kinds on the market. Connecting directly is accomplished by flexible couplings or magnetic clutches. Two years ago an extensive addition was completed at this mill and all pumps and fans that could be direct-connected without too expensive a layout, were thus connected. These direct-connected machines have caused very little trouble and the operating expenses have been small as compared to some of the older belt- or gear-driven apparatus. The cost of driving power is much less, as the friction load was reduced by eliminating belts and countershafting. The mill load totals over 15,000 hp. of electrically-driven machinery and a reduction of 1 or 2 per cent of the friction load means a substantial saving in the power bill.

Question 5.—In making routine tests of motors for power consumption or load, we use a Weston polyphase wattmeter, with variable-ratio current transformers. The potential coils of this meter are wound for 600 volts and as our motors are all 550 volts, with the exception of a few large ones, it is not necessary to use voltage transformers. We usually connect a pair of ammeters in series with the wattmeter current coils and then by using a voltmeter the power factor is easily determined and we always have proof of the correctness of our meter readings. For special tests where load and variations are required over a long period of time a General Electric graphic meter is used. For insulation tests a Megger is used and all the large machines are given periodic tests. In case of doubt on any of the small motors, the Megger is again brought into service. We find this to be a very useful instrument in the repair shop on both new and repaired windings or other equipment requiring a high-potential test. The Megger determines the condition of the insulation and if it is in good shape the apparatus is given a high-potential test.

Question 6.—Our repair shop is not very well equipped as plans are under way to build a larger, better shop in the near future and then to purchase the necessary shop equipment. We have a few pieces of shop equipment which, while made in the shop, serve the purpose very well. For winding coils of the many different sizes and shapes required we use an adjustable form on which both coils for open and semi-closed slots are made. In winding the coils for open slot machines the conventional loop is wound and after taping the coils are pulled to shape by hand. Coils are dipped in varnish and baked over a steam-heated coil before placing in the motor. Several methods of applying the varnish and several kinds of varnish were used on closed slot coils before we found one that suited all conditions.

We had a great many old motors with soldered rotors and as these were a constant source of trouble a remedy was needed. Several of these rotors were welded and the results were so gratifying that the practice was continued. Today we have very few rotors which give trouble. As soon as one shows signs of trouble the motor is replaced and the troublesome rotor is welded. Many seem to think that welding does not pay, due to starting difficulties. Rotor welding should be done only by a welder who knows this work. Any good welder can make a tight job, but a good many put on so much metal that the resistance of the rotor is lowered unduly. We have had not less than twenty rotors welded and in no case have we had starting difficulties.

In the shop we use a portable spray-gun outfit manufactured by the DeVilbiss Company, Toledo, Ohio. Motors showing signs of oily insulation are dried out and sprayed with Sterling varnish or Ohmaline No. 68, an English varnish that is pliable.

* * * *

J. Elmer Housley, Electrical Engineer, Aluminum Company of America, Alcoa, Tenn.—The time-tried watchword of the plant engineer is preventive maintenance. Nearly every machine gives evidence of distress before failure, either by sound, smoke, vibration or during regular testing by proper meters. Where operation is forced and a suitable occasion is not presented for inspection and repair before failure occurs, one failure may be excused. Why should there be a second failure? Usually because the underlying cause is not discovered. If there is a shaft out of true, a pump out of balance or any other condition existing that is *the* cause, there can be no elimination of the effect, such as burned bearings, until the cause is discovered and removed.

Maintenance should be given more consideration by the designing as well as the operating engineers. Should troubles develop that were not foreseen, the necessary cost of revision is nearly always repaid in a short time by savings in maintenance and in delays.

One noteworthy advance in maintenance methods is the increasing use of the electric arc welder, with excellent results in general plant repairs; the use of the welder frequently invades the fabrication of sheet metal parts after it is once in the plant.

Repair costs are being lowered by mechanical transmission devices for reducing the speed between motor and machine. A good flexible coupling is a very necessary adjunct to take care of shocks during the starting of the motor. In the short period that the new type synchronous motors, with clutch devices for giving high starting torque, have been in service they have made a good impression and offer an effective method of reducing distribution and wiring costs and improving voltage regulation.

* * * *

William J. Mildon, Superintendent of Power and Equipment, Madeira-Hill Coal Mining Co., Philipsburg, Pa. *Question 1.*—Maintenance and repair work are under the supervision of the Chief Electrician or Master Mechanic at each mine, or mines, where there are more than one in the vicinity. Their assistants are promoted from men having experience in the operation of the equipment. The number of men required is determined by the size of plant and ranges from three to twenty.

Question 2.—Savings in maintenance and repair costs have been made by standardizing on equipment best suited to the various requirements, scrapping obsolete apparatus, making periodical inspections and permanent repairs instead of temporary ones. Also, the installation of a 300-hp. cylindrical conical drum hoist, having all wiring in conduit, soundproof apartment for primary and secondary contactors and a resistor rack to facilitate inspection and removal for repairs has saved us money.

Question 3.—The equipment causing us most trouble is the gathering pumps. The trouble is of a mechanical nature, due chiefly to the severe operating conditions, caused by continuous service and infrequent loads through pumping a mixture of air and gritty water, thus cutting packings and cylinder liners.

Question 4.—A marked saving in operating cost was made by the installation of an automatic auto-starter on a 25-hp., 2,200-volt fan motor, which is located two miles from the main plant. A saving was also made by the application of a silent chain drive to replace spiral gears which caused too much end thrust on motor bearings, resulting in vibration of the rotor. The application of 99 per cent nickel to replace acid-resisting bronze on heavy-duty, high-speed, centrifugal pump rotor parts, such as shafts, impellors, labyrinth rings and wearing sleeves, has netted a saving in maintenance amounting to over 400 per cent in two years; the last inspection showed no signs of wear.

Question 5.—Testing equipment that we have found of much value in inspection and maintenance as well as for power and load tests are, a fault-finder or 50,000-ohm magneto for locating trouble; portable, d.c. voltmeters, millivoltmeters, and ammeters; portable a.c. voltmeter and potential transformers, ratio 20-1; portable 0/5, 0/10 amp. ammeters; and 5/25, 50/100-amp. current transformers.

For installation tests the Esterline Utility Graphic wattmeter is used in conjunction with the above indicating instruments and is the most valuable of instruments for the reason that periodical tests may be compared.

For testing insulation we use the voltage drop test in conjunction with an adjustable resistor, or load box and ammeter. We use a recording voltmeter for testing line voltage, with multipliers for a.c. or d.c. If a test is to be made only for power consumption, we use watt-hour meters.

Oils from transformers, oil switches and circuit breakers are tested periodically with a General Electric portable oil testing cup and transformer. The oil under test must not break down below 17.5 kilovolts, when using 1-in. discs separated 0.1 in. in the testing cup, to be considered in fair condition. Below that standard, the oil is filtered.

Question 6.—The equipment in our repair shops consists of thread-cutting engine lathes with taper attachment, drill presses and radial drills, shapers, milling machines, emery grinders, portable electric drills and hammers, portable keyseating machines for field work, portable electric grinders for truing up large collector rings and commutators in their bearings, electric mica-cutting saws for slotting commutators, and electric welders having a range of 15 to 250 amp.

The portable acetylene cutting and welding torch is without question the most valuable piece of equipment in the electrical and mechanical repair shop. It can be used on more jobs than any other tool and is also the most convenient and flexible in reaching an ordinarily inaccessible location.

* * * *

H. D. Fisher, Plant Engineer, New Haven Pulp & Board Co., New Haven, Conn. *Question 1.*—We do not have a very formal organization, as we have a comparatively small plant. Our plant is arranged so as to form two practically separate paper mills, in each of which we have a millwright who is responsible for the upkeep of the equipment, with a total of four helpers who are distributed as needed. For general service for both mills we have a machinist, an electrician who has a helper, when needed, a steamfitter with one to three helpers according to the amount of work in progress and a bricklayer for boiler wall maintenance and general building repairs. Our reason for carrying such a variety of help is that paper mill operation is continuous, 24 hr. a day, so that it is necessary to have sufficient men available to make repairs while the machines are shut down. In order to employ them economically during the week and also have them on hand in case of accident or emergency, they do most of the minor alterations and construction work and also make up as many repair parts for machines as possible.

Question 2.—Periodic, careful inspection and a policy of replacing material before it gets to the breaking point has done the most to reduce repair and upkeep costs.

Usually some parts can be bushed or renewed and kept for spares, while if left alone until breakage ensues they are junk. Probably our most remunerative single change was driving the compensating shaft winder by a motor instead of directly from the paper machine engine, and replacing the cast-iron pinions of the differential mechanism with steel pinions. Formerly at times we broke three or four pinions a week, costing $5 to $10 apiece, but since using steel pinions, and a motor drive, which gives a smoother, less jerky pull, we have lost only one steel pinion. Trouble with the main cast-iron gears, which we thought possible with the greater stresses transmitted through the steel pinions, has not materialized. We have also saved about half of a man's time replacing gears. Just at present we are having considerable trouble with a 24-in. vertical belt drive, having 20-ft. vertical centers, and 3-ft. horizontal centers. This belt, which runs on a 46-in. upper pulley turning at 150 r.p.m. and an 84-in. lower pulley having a speed of 82 r.p.m., and transmits 100 to 125 hp., gives us more trouble than any one piece of apparatus. I am using a rubber belt at present but expect to substitute an endless leather belt.

Question 3.—We have replaced several small steam turbines driving heating fans with variable-speed, slip-ring motors, with considerable economy and convenience, as the motors require less attention than the small turbines.

Question 5.—Our principal requirements are power and speed, so that our most-used portable testing equipment is an Esterline graphic wattmeter with universal transformers and a recording tachometer. We also have and use a steam flow meter and pressure recorder for special tests.

Question 6.—Our repair shop equipment is exclusively mechanical as with about 50 motors aggregating 3,000 hp. in service, we average only about three rewinding jobs a year, and with the excellent local facilities we cannot afford to try to do such work.

* * * *

R. N. Vining, Electrical Engineer, Detroit Seamless Steel Tubes Co., Detroit, Mich. *Question 1.*—Successful maintenance of electrical equipment consists essentially of three items: First, and most important, systematic inspection with an effort to avoid breakdowns; second, trouble shooting and repairs; third, operation, including oiling, cleaning, switching, etc.

The number of men required in the maintenance force is more exactly determined in the reverse order. The

power house and each substation require an operator to start, stop and care for the machines. It is seldom possible to use one man for more than one station on account of the relative locations. Each station is generally of such size that one man can handle the electrical equipment. The maintenance electricians answer all trouble calls by locating the trouble and repairing the equipment, if practical, without removing it from the job. These men are generally grouped in pairs, an electrician and helper forming a unit. The repair shop men do the motor winding, switch and controller overhauling, restacking of grids and other general repair work. The maintenance electricians frequently have time during the day to make inspections over some section of the factory. This inspection is arranged as closely as possible to cover weekly all motors in the mill as to general inspection, operation, load conditions, and condition of motor and control both electrically and mechanically. As often as possible air gaps are checked for bearing wear and equipment is checked for grounds and insulation resistance.

Question 2.—With a.c. motors, our largest savings in maintenance costs have been made by frequent checks of the bearing wear. The inspector is supplied with a thickness gauge consisting of seven leaves. These feelers are in thicknesses of 8, 10, 12, 14, 15, 16, and 18 thousandths and are each 12 in. long. The gage is of General Electric Company manufacture and known as Cat. No. 2155371G1. General tests of insulation have also shown marked savings.

Question 3.—We have experienced considerable trouble with a group of multi-speed, three-phase, a.c. motors operating cut-off machines. There are so many leads, 14 in all, and controller connections, 18 fingers, that we frequently have single-phase operation. Direct-current motors are better adapted to this service.

Question 4.—One of the most important improvements in the last few years, in the way of protection to the smaller motors, is the development of the thermal cutout relay. These relays have proven particularly effective on the cut-off drive just mentioned.

Question 5.—Our most valuable testing equipment is: an a.c. ammeter with multiple-tap, slip-on transformer having ranges from 5 to 400 amp.; a d.c. millivoltmeter with shunts of 10-, 100-, 200-, 500-, and 1,000-amp. capacity for measuring current; and a multiple-leaf thickness gage for measuring air gaps. A Megger is also particularly valuable for insulation testing. A portable graphic millivoltmeter used with shunts in measuring d.c. current, together with a multiplier for d.c. voltage and a magneto driven from the motor under test as a means of recording speed, are also of great help.

Question 6.—One of our recent additions to the repair shop is a standard gasoline torch fitted with a special air connection on the back of the burner. A small copper tube acts as a syphon to the gasoline section. By this means a spray of gasoline under pressure can be applied to armatures and other equipment for cleaning purposes, with a considerable saving in time and expense over previous methods used.

* * * *

H. E. Stafford, Electrical Engineer, Provincial Paper Mills, Port Arthur, Que., Can. *Question 1.*—The plant with which the writer is associated has a connected load of approximately 7,400 hp. in a.c. motors and 350 hp. in. d.c. motors. We have 155 motors of ½ to 1,400 hp. capacity.

These motors are inspected once every 24 hr. Each motor is numbered and a card, shown on page 72 is placed at each motor. The inspector checks off on this card the different items inspected and at the end of two weeks the card is brought into the office. This plan insures that the inspector gets to each motor and being at the motor makes it easy to look it over. This system has worked out very well and the daily inspection brings to light various troubles that would otherwise cause a shutdown were they not detected early.

Question 2.—A power survey was made of the plant last February and March, and a small number of changes were made. Due to increasing the number of agitator blades and the size of pump impellors some of the motors were considerably overloaded, while others had their load reduced. In one or two cases it was possible to switch motors, as the speeds were identical and the horse-power was right for the load. In other cases it was necessary to use reduction gears, while in two cases the speed and horsepower of the motors were changed.

In order to be insured against shutdowns of motors of different speeds and ratings, but of the same frame size, the writer re-arranged a stator to develop two speeds, 900 and 1,800 r.p.m. and another stator of the same frame size for speeds of 600 and 1,200 r.p.m. By making a few changes in the sizes of pulleys, these stators may be used to replace the stators of 25 motors of 5 to 25 hp. capacity, with speeds ranging from 600 to 1,800 r.p.m. Probably this is the most outstanding convenience in the electrical department of this plant, as an outlay of about $500 insured 25 motors against shutdown longer than the time necessary to change stators.

Question 3.—In a pulp and paper mill, water is the worst enemy of electrical equipment. To safeguard against water from hose nozzles, bursting pipes, and overflowing stock pits, the majority of motors and starting equipment is covered with metal housings properly ventilated and accessible for oiling and inspection.

Considerable trouble was encountered with the starting resistances of d.c. motors burning out, due to the controller handles being left on some of the intermediate steps. By replacing all resistances so affected, by others of greater carrying capacity, it is possible to leave the controller at any step for an indefinite period without any damage to equipment. Considerable time has been saved since the installation of these resistances and the cost of replacements saved, has more than paid for their initial cost.

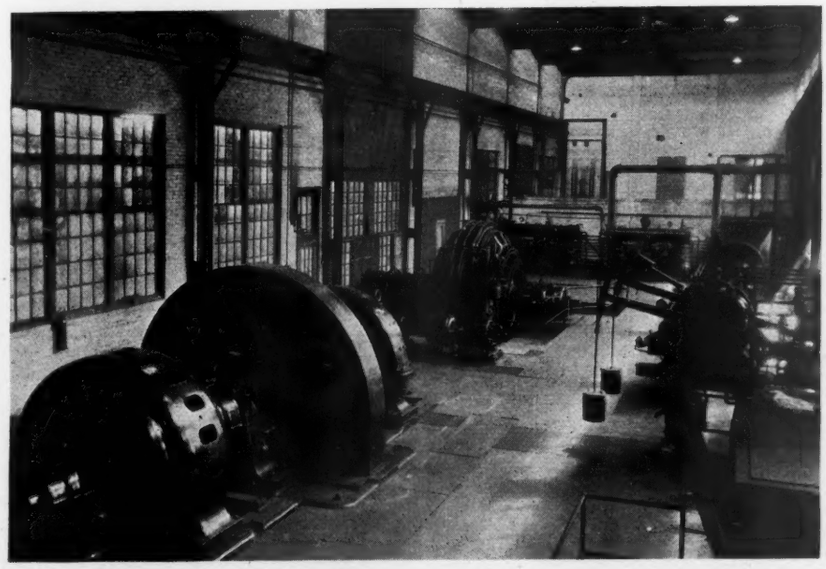
Neglect and carelessness may be said to be the contributing cause of 90 per cent of equipment failures. Neglect of bearings, using too much or too little oil or the absence of the use of feelers for air gap measurement are contributing causes of motor failures. Overfusing and tying-in of starter handles are contributing causes of not only motor failures but controller failures as well.

Question 4.—There have been no radical changes in the mechanical and electrical drives of this plant of late, but provisions have been made for changing the drive on two beaters from belt to silent chain. The space occupied will be much less, the drive more positive and replacements fewer, besides better operating conditions.

Question 5.—The apparatus for load testing consists of a panel-mounted graphic wattmeter, graphic kva. meter,

Operating delays on equipment of this nature are being prevented by thorough, systematic inspection.

The maintenance methods used in the Blooming Mill Substation of Follansbee Bros. Co., Toronto, O., are given in J. C. Murray's comments on page 67.



integrating watt-hour meter, indicating wattmeter, indicating power factor meter, voltmeter and ammeters. The portable instruments consist of three current transformers, two potential transformers, a power factor meter, wattmeter, voltmeter and ammeter. For insulation testing, an Evershed megger is used. All the above apparatus is used at regular intervals for a general check, or as often as emergency cases warrant.

Question 6.—The electrical repair shop is equipped with a portable winding table and chain block, a portable air compressor for blowing out motors and running small air tools, an impregnating tank for small and medium-sized motors, an electric oven for baking and drying motors and equipment, an emery wheel, complete set of pipe fitting tools and commutator stones for all sizes of machines in the plant. The air compressor mentioned above can be taken to any part of the plant. The baking oven is of 5-kw. capacity, built up of Cutler-Hammer space heaters and provided with a portable hood.

Probably the greatest saving in time and equipment has been made by the portable air compressor which, equipped with 250 ft. of three-conductor cable and 150 ft. of air hose, can reach the remotest and most inaccessible motor in the shortest possible time.

* * * *

W. W. Lankton, Assistant Electrical Engineer, Detroit Copper and Brass Rolling Mills, Detroit, Mich. *Question 1.*—The electrical work in our plant is handled by a crew of 19 men exclusive of crane operators, of which there are seven, and one girl for office work. This includes the Electrical Engineer and assistant, two construction journeymen and two helpers, five maintenance men, one for each mill and two for night duty, one armature winder and helper, three repair shop men, one of whom has charge of all instruments, meter repair and testing, and one stock man.

The most effective distribution of maintenance work that we have found so far is to make one man directly responsible for all electrical maintenance in one section of the plant. He has his headquarters at the substation in his section and is thus available for all trouble shooting or minor repairs. If extra help is needed a telephone call to the shop brings a repair man.

This direct fixing of responsibility, in connection with daily written reports from each maintenance man to the office of the Electrical Department, produces excellent results. These reports are not intended to be lists of the number of hours spent on different kinds of work, but include delays to productive machinery, with length of time thereof and causes; also, all unusual troubles, or ordinary trouble which is constantly recurring and might be remedied by some change in apparatus or otherwise, and in fact any information of interest.

Question 2.—Large savings in maintenance costs have been made by the installation of overload relays on all motors. These have reduced our trouble calls by 60 per cent.

Fused switches are used for line protection and all starting units are made up with non-fused disconnecting switches of the safety type. In the case of phase-wound motors in sizes up to 100 hp., all the starting equipment is assembled in one frame as a unit. The disconnecting switch, oil switch with overload relays, controller and starting resistor are all mounted compactly on a pipe frame with base made up of channel iron.

We have used the standard types of renewable fuses since these were first placed on the market and have found them very satisfactory when properly refilled. Our practice has been to have all blown fuses brought to the shop where they are thoroughly cleaned and refilled by one man. After filling, the ferrules or contact blades are polished on a small buffing wheel and the fuses are placed in racks marked with the different sizes. The current rating is also stamped on all shells to avoid any mistakes in size.

Six steam engines ranging in size from 300 to 1,500 hp. have been replaced by electrical drives in our plant since 1918. One of the latest and possibly the most interesting of these installations is partially shown in the illustration on page 73. The rope drive was on a hot copper rod mill intermediate and run-down drive and was replaced by a two-motor and Falk herringbone gear drive, as shown under construction in the illustration at the left. The motors of 400-and 200-hp. rating, are connected to opposite ends of the same shaft and either one or both may be run according to the load requirements. The controls are interlocked so that the 400-hp. motor is always started first and when both are running either may be tripped off as desired. One great advantage of this arrangement over a single motor drive is that better power factor and efficiency conditions are obtainable due to the fact that the motors can be run at or near full load, under conditions of light load on the mill, the mill load varying with the size and shape of the bars.

The break-down unit of this mill, which was driven by the same engine, was replaced by a single 300-hp., phase-wound motor with Falk gears and flywheel. A small amount of fixed resistance made up of flat bars of nickel silver is connected in the secondary leads of this motor to enable the flywheel to absorb the peak loads of short duration.

Question 5.—A fairly complete line of testing equipment is essential in any large industrial plant, but the two instruments which have been of the most outstanding value are the curve-drawing wattmeter for study of load conditions on all sizes of motors, and the Megger for testing insulation resistance of large generator and motor windings, and high-voltage, lead-covered cables, particularly at the time of installation or repair.

The aforementioned graphic wattmeter is arranged to be direct reading on all sizes of motors. This is accomplished by means of one pair of plug-type current transformers which are adjustable to ratios of 25/5, 50/5, and 100/5 amp. and one pair of 1,000/5 split-type current transformers which may be adjusted for ratios of 500/5 or 250/5 by looping two or four turns of cable through them for the primary. The direct reading feature is obtained by a series of chart rolls, one corresponding to each transformer ratio. This direct reading of the chart without the use of multipliers is of inestimable value when discussing load conditions, etc., with company officials,

This motor inspector's report, covering a period of two weeks, is used in a paper mill.

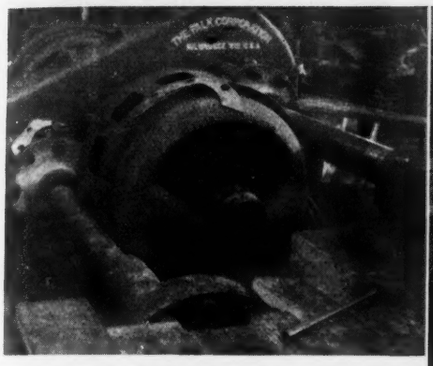
Details regarding the use of this form are given in H. E. Stafford's comments on page 71.

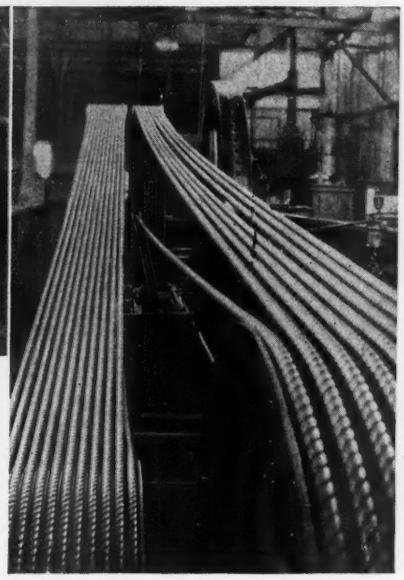
2 WEEKS ENDING Dec 19. 1925 — ELECTRICAL DEPARTMENT DAILY INSPECTION CARD — FORM 295 — MOTOR NO. 148

	A. M. 7	8	9	10	11	12	P. M. 1	2	3	4	5	6	CONDITION	CLEANED	OILED	INSPECTOR
MONDAY								X					Good	Yes	Yes	Rickard
TUESDAY								X					"	No	No	Rickard
WEDNESDAY								X					"	"	Yes	Rickard
THURSDAY								X					bearing in bad condition		Yes	Rickard
FRIDAY								X						no	No	Rickard
SATURDAY								X						"	Yes	Rickard
MONDAY								X						Yes	Yes	Skipton
TUESDAY								X						No	No	Skipton
WEDNESDAY								X						"	Yes	Skipton
THURSDAY								X						"	No	Skipton
FRIDAY								X						"	Yes	Skipton
SATURDAY								X						"	No	Skipton
								X								

FOREMAN'S SEMI-MONTHLY REPORT Pulley and bearing changed Thur
Motor in good condition

J. Wackstrom FOREMAN





Change from rope drive to geared motor drive resulted in marked economies in a hot copper rod mill. This mill in the plant of the Detroit Copper & Brass Rolling Mills, Detroit, Mich., was originally driven by a steam engine through a rope drive, as shown in the illustration at the right. This was replaced by a Falk reduction gear driven by two wound-rotor induction motors connected to the same shaft, as shown in the left-hand illustration.

as the data when presented in connection with the chart are thereby made more convincing.

The curve drawing meter also has a peculiar psychological effect. Whenever it is being set up on a motor-driven machine, the operator almost invariably goes over his machine very carefully, oiling all parts and looking over belt and pulleys. In some cases of overloads, the trouble is immediately rectified in this manner.

Question 6.—In our winding department we are using the Segur coil forming and taping machines and a coil winder of the Segur type; also a portable Franklin crane for handling motors and heavy parts. All new windings are dipped or sprayed and baked in an electrically-heated oven which we have constructed ourselves. The latest valued addition to our equipment in this department is an oxy-acetylene lead-burning torch for use in soldering coil clips, etc. This is particularly valuable for use on the coil clips of large rotors.

* * * *

Lyle Hendricks, District Electrician, Pickands, Mather & Co., Hibbing, Minn. *Question 1.*—The supervision of the electrical and mechanical equipment at all of our properties comes under the jurisdiction of the Chief Mechanical Engineer at our general office in Duluth. This includes twenty-five iron mines in Minnesota, Wisconsin, and Michigan. District Electricians or Master Mechanics are directly in charge of their respective equipment in the different districts into which this territory is divided. One or more mine electricians and helpers are located at each of the mines having sufficient electrical machinery to warrant their employment. These men form a district gang, and are moved from mine to mine on the larger jobs. The fact that the work is seasonal, having an operating season of only six months at most of the mines, makes it very difficult to form a permanent organization.

Questions 2, 3 and 4.—The electrification of the underground mines has been very largely carried out and has shown important savings in operating costs. Probably the most important of the recent changes in mining methods has been the introduction of slusher loading to replace hand shoveling. Both air and electric tuggers are used, but as the power cost ratio is about 18 to 1 in favor of the electric, the air tugger is fast becoming obsolete. Both the haulage and slushing equipment are handled by inexperienced labor and require considerable maintenance. Trolley and light wiring underground require a great deal of attention, due to the heavy caving conditions.

The electrification of the open pits is of a more recent nature but bids fair to be more important than that of the underground mines. Electric shovels of all sizes have been introduced and are proving superior to the steam shovel, both in point of economy of operation and reliability of service. This applies especially to the large revolving shovels. Electric blast hole drills of the well-rig type are generally used and give very good service. Their superiority is especially noticed during the winter. Power for both electric shovels and drills is provided through rubber-covered cables, and these cables receive very severe service. Electric locomotives are used at some of the mines and one pit is completely electrified. Crushing and washing plants are used at some of the mines and in all cases are completely electrified. Practically all open pit machinery requires a great deal of maintenance due to overloads, abuse, exposure, etc., and quick repairs are essential.

Question 5.—For the maintenance of our electrical apparatus we have the following equipment; oil testing transformer, portable "Meg" insulation tester, rotating standard watthour-meter indicating ammeters and voltmeters and the necessary instrument transformers. Transformer oil is tested yearly, and the insulation resistance of the larger electrical apparatus is measured just before the spring operating season. Watt-hour meters are tested every year and the resistance of pipe-driven grounds is measured during the dry season.

Question 6.—At present we do not have a fully equipped district electric shop, but have small shops at the mines and repair work is carried on in connection with the machine shops.

* * * *

A. Hauswald, Chief Electrician, De La Vergne Machine Co., New York, N. Y. *Question 1.*—The company with which I am associated, builds refrigerating machines, installs ice plants, and builds and erects oil engines of the Diesel type, made in sizes from 40 hp. to 1,000 hp. This company employs 350 men in the shops.

The maintenance work in the Electrical Department is taken care of by three electricians and myself. Rewinding of armatures is let out on contract, as it does not pay us to do this class of work; we seldom have a breakdown of this kind.

We generate our own power and deliver about 1,000,000 kw.-hr. yearly to the shops and offices for light, heat and power.

Question 2.—In the past two years I have made several changes to the electrical equipment, which have resulted in a saving of time and money. For instance, I have a clock and periodograph time-recording system which were operated from a 48-volt storage battery. This battery also furnished current for bell systems and a watchman clock system. I revamped the various circuits by re-connecting them from a straight series system to a parallel-series system. By doing so, I eliminated one 24-volt storage battery, plus half of the time that would be spent in locating trouble on the straight series system when an open circuit occurred.

Question 4.—We have installed two new 15-ton Niles cranes during the past two years, one in our erecting shop, where engines are set up for test. Now, to speed up this work, we have two cranes operating on the same rails in the one shop. None of the mechanics on the test floor has to wait for crane service.

Another 15-ton crane was installed in the yard where engine frames and other castings are stored.

A new 4-ton electric elevator was installed to replace an old 2-ton hydraulic elevator which was in service some 35 years. The new electric elevator is of higher speed, which also speeds up production.

Several very old motors were scrapped, due to the fact that the upkeep was high, because they were troublesome and delayed production and increased maintenance costs. These were replaced by spare motors which I had on hand and which were in better shape than the old ones.

Question 5.—I have several graphic meters, voltmeters, ammeters, all of which are of the direct-current type, and are used for testing. We also have a Standco Megohmmeter which is used to check insulation resistance and can also be used as a voltmeter. I find this latter instrument a necessity for measuring the insulation resistance of motors, generators, and power circuits.

A. B. Adams, Electrician, Elgin National Watch Company, Elgin, Ill. *Question 1.*—The general formula for successful and economical electrical maintenance in a watch factory is in no way different from that of any other manufacturing institution. While it is true that the apparatus may not be as complicated or in such large units as in steel mills, automobile factories, and the like, certain rules must be laid down by the management and rigidly enforced, to lessen the personal injury and fire hazards.

Notices are posted in conspicuous places in every department in this factory warning the employees not to meddle or attempt to make any electrical repairs; they are forbidden even to take a shade from its holder—this is a rather drastic rule, but it brings in 100 per cent interest each year.

Our power plant furnishes current for about 8,000 lamps and about 300 a.c. motors ranging in size from 1/30 to 175 hp. About 95 per cent of these motors are of the three-phase, 60-cycle induction type. All new motors are taken apart and given a rigid inspection, the rotors are tested for poise and loose bars, and the oil grooves in the boxes are enlarged in many cases. Any unusual noises in operating motors are reported and depth gages are used to find if this is due to improper clearance between the rotor and armature. A difference of 0.01 in. in gap over the original measurement is all that is permissible, and new bronze boxes are installed when this value is exceeded. Wattmeter readings are made when motors are put in commission, to insure that they are not overloaded.

Question 2.—Due to the oil used, in 15 years there have been no frozen boxes, and lubricating troubles are a thing of the past. All motors are oiled each week and where possible oil gages have been installed to show that the proper level is maintained. Nearly all motors are hung upside down and fastened to the ceiling beams; the use of portable hoisting elevators has made the installation of them a simple and easy job. Idlers are installed wherever possible and the ceilings over the driving line shafts have been recessed to permit the use of 36-in. pulleys. This makes possible the use of a larger motor pulley, and they are made wide to insure good traction. A few years ago many motors of the double-drive type with 4-in. pulleys were in use, but these have been altered to a single drive, as it was found difficult to get two belts on the same size pulleys, and connected to the same lineshaft, to pull alike.

Question 3.—In this plant there are in operation hundreds of automatic machines and lathes, most of which are push-button controlled. Each machine has a tell-tale lamp which lights when the machine automatically shuts down on account of running out of stock, broken drills, or other troubles. Nearly all of these machines are piped for oil and compressed air, and the room as a result is heavy with vapor. The oil in time eats all the insulation from the wires and leaves just the outside linen braid for protection. There were several small fires as a result of grounds and short-circuits, and many calls for service. At the present time all machines are wired with white-braid Underwriters' wire, which is impervious to oil, and shutdowns have been reduced to a minimum. On many of these machines a very high speed is maintained and a very small chip is turned from the stock. These chips resemble particles of fine emery dust. This dust would mix with the oil and work into the bearings, causing continual repairs to spindles and revolving heads. To correct this, all oil is now run through a succession of felt filters and over a huge electromagnet measuring about 8 ft. in length and 12 in. wide. At this point the steel chips stop and the clear oil is pumped back to the machines.

Another disturbing element to the maintenance man is the burning out of immersion coils which are used to heat oil to a temperature up to 475 deg. F. Thermometers were placed in the oil kettles and the operator was supposed to pull the switch when the high mark was reached. Sometimes he did, and again he did not until the oil was almost at the flashing point. There is no guesswork now; automatic relays and thermostats regulate the heat. The cost of this apparatus ran into money, but it pays big dividends.

One of our most persistent troubles was the adjustment of the department gongs, which ring six times each day. These were continually needing adjustments. Alternating-current siren horns have been substituted and after four years of service none has yet been taken down.

Starting compensators with automatic no-voltage release have been a great help. Most of the automatic machines require a uniform speed for successful operation, and functioning of an overload relay would prevent broken drills and cutters and hours of labor resetting new ones.

Owing to the smallness of most of the work throughout the factory, each machine inspector or operator requires an individual light or two. General illumination is used only in the offices. By a special ruling of the Underwriters, drop cords with adjustable weights and pulleys are in general use. The weight cords are all double-tied and wired against untying.

The maintenance force consists of four men who do all the repairs and new wiring for lights and motors on Company property. During a period of 20 years on the job, the writer knows of no shutdown or loss of time that could be attributed to poor or careless work, and no employee has ever been seriously injured.

* * * *

Nathaniel H. Case, Chief Electrician, Wyckoff Drawn Steel Co., Ambridge, Pa. *Question 1.*—We have installed in our plant 85 a.c. motors ranging in size from ½ to 100 hp., 30 d.c. motors ranging from 1 to 70 hp., 16 electrically operated 2- and 3-ton hoists, and one 10-ton crane. As our plant is still expanding, construction, maintenance, and repairs are handled by the same men.

Question 2.—Data cards are kept on all repair jobs, such as changing oil in bearings, auto-starters, compensators, replacing bearings, brushes, new parts on hoists, cables, etc. A glance through the card index may show a certain hoist using more cables than others. An examination of the drum on this hoist may prove that the grooves have become worn to such an extent that the edges are very sharp causing a shearing motion, which cuts the outside cable strands, causing the cable to wear out much faster than necessary. Under these conditions we find our index a guide against bad break downs, and also a money saving scheme on repairs.

Data cards are also kept on chains, showing the location of the chains, when annealed, repaired, etc.

Much expense has been saved in repairs to motors by cutting out defective coils from d.c. armatures and also stator coils from a.c. motors. We have been operating a 10-hp., 440-volt a.c. motor for over a year with seven coils cut out, and it is still going good.

By the use of commutator stones we have been able, by touching up our commutators now and then, to operate our commutator and slip ring motors for a period of six years without having one turned in the lathe, which we all understand takes a considerable amount of life from a commutator. Hence we figure the stones a very good investment.

Question 3.—Our monorail hoists consist of two 3-ton hoists mounted on the same beam, one 10 ft. in front of the other and connected together by means of a steel bar. The trolley motors are connected in series so that both may have the same speed. This outfit was at first operated on the lower flange of a 10-in. I-beam. Due to the sharp curves and the frequency of the trips, the flanges of the I-beam became worn and sharp, which soon cut the flange of the wheels to such an extent that the hoist climbed the beam flange, causing cutting of the side casting and placing the hoist in a position to snap a casting and fall to the floor. This was overcome by placing 16-lb. rails on the lower flange of the beam. Wider flat wheels were installed in place of the bevel track wheels formerly used. This gave us a wider working surface, longer lived wheels, and longer lived track.

Question 5.—We use both a.c. and d.c. portable voltmeters and ammeters for testing individual motors in order to obtain load characteristics of each machine. A record is kept of the different tests showing the load, speed, and the amount of work done under these conditions. It often occurs that a certain amount of work must be done in a certain time which would require pushing the machine. A glance at the data card listed under this machine will show just what the machine will stand. Under these conditions if a machine is loaded to full capacity or over, every one concerned in its operation is aware of the fact and knows it will stand watching. This is, to our knowledge and experience, a much safer and more economical method of operation, than to slam a big load on a machine blindfolded, and then when something breaks it is discovered that the load was too much for the motor.

Fig. 1—Refinishing the walls and ceilings will improve their reflecting qualities and increase the effectiveness of the lighting system. Grimy, discolored, or dark-colored walls and ceilings reflect light poorly and give an unattractive appearance to the factory. Painting with light-colored paint greatly improves this situation. In this illustration, paint spray guns are being used to speed up and cut the cost of the painting operation.

How to Get the Most from Your Lighting System

together with a discussion of what better lighting costs, how much better lighting is worth to you, and maintenance methods that will improve faulty lighting conditions in your plant

By ROY A. PALMER
National Lamp Works of General Electric Company, Cleveland, Ohio

COST is usually the basis for the most strenuous objections on the part of the operating executive to installing a new lighting system or revamping the existing installation. However, in spite of the fact that better lighting apparently costs more than poor lighting, a close analysis will almost always prove that poor lighting is really more expensive than good lighting.

The lighting system of a factory should be considered as important as a labor-saving machine, rather than as an expense-building item. When new improvements are brought about in a machine so that through economies in labor and in time, it can be made to pay for itself within a reasonable period, the old machines are promptly discarded in favor of the new machines. Better lighting has demonstrated its effectiveness in increasing production, decreasing accidents, and in many other ways benefitting the factory owner and worker. These benefits are the dividends from an investment in better lighting which more than pay for the added cost.

The cost of lighting is usually compared with the payroll, since wages are one of the major items in production expense and it is possible by this comparison to determine the value of light in aiding production. For example, a worker paid at the rate of 60 cents an hour receives one cent a minute. A 200-watt lamp will provide illumination for the worker and will cost less than 5 cents to operate for a period of 8 hr. If through the day, the worker should lose 5 min. in groping about for tools or material hidden by dark shadows because of poor lighting, the cost of a whole day's light is lost. If, on the other hand, his actions and speed of vision are so increased by better lighting that he is able to turn out 10 per cent more work, the cost of the lighting is paid for many times over. In the nine tests which have been previously mentioned in this series of articles,

the average increase in production resulting from better lighting was 12.2 per cent while the increased cost of lighting averaged 1.96 per cent of the payroll.

Thus we see that if increased production were the only benefit resulting from better lighting, it would pay to equip a plant with the best lighting system obtainable. Fortunately, the reduced number of accidents, less spoilage, improved product, better working conditions and satisfied employees are additional benefits which result from better lighting and which help to justify the added cost. These benefits are obviously difficult to evaluate in dollars and cents, but nevertheless they are worthy of serious consideration. The cost in lost time and in compensation for a single accident which might be caused directly or indirectly by poor lighting would perhaps pay the cost of good lighting for a whole year.

For many years past, there has been a constant rise in living costs, which reached a peak shortly after the war. The cost of light has, however, declined and at the present time it costs less to operate a 100-watt Mazda lamp than it does to burn a wax candle.

The reduction in the cost of light can be attributed to three factors: (1) Reduction in rates for electric energy. (2) Improvements in the efficiency of lamps. (3) Reduction in prices of lamps.

Notwithstanding the fact that the cost of fuel has almost doubled since 1914 and that labor and supplies have increased considerably, the rates for electric energy have remained practically constant since 1914. Previous to this period, there had been a reduction in the rates for electric energy in each year since electric lighting was first used.

Improvements in incandescent lamps have been such that more light is obtained for a given consumption of current. Since in many cases the cost of lamps is, according to the National Electric Light Association, less than 10 per cent of the total bill for electric current, the improvements in the efficiency of a lamp are important. Better manufacturing methods and the greater use of labor saving machinery have brought about a reduction of 37 per cent in the prices of lamps during the past two years.

With the improved efficiency and the low cost of lamps and the low cost of electric energy, artificial light is cheaper now than it has been at any other time. In Fig. 2 is shown how these changes have taken place during the past forty years. In view of the fact that good lighting can now be obtained so cheaply, it should be the duty of every industrial executive to provide lighting systems in his plant which are of the most modern design.

Do Not Let These Items Steal Light in Your Plant

(1) Dirty reflectors and lamps.
(2) Darkened walls and ceilings.
(3) Depreciated lamps.
(4) Empty sockets.
(5) Unobserved burnouts.
(6) Improper size or wrong voltage applied to lamps.

Because we have always built our homes and buildings so as to utilize daylight to a considerable extent, we rarely think that daylight in interiors costs money. In a paper outlining an investigation of the cost of daylight, Messrs. Luckiesh and Holloday showed that in general, daylight costs about the same as electric light. Large window areas and skylights cost more than walls or roofs; heat losses occasioned by glass are sometimes an item of expense; cleaning and repair costs are perhaps the largest expense, while consideration should also be given to the investment in ground area occupied by light courts. All of these factors are chargeable to daylight and hence due weight should be given them when planning the lighting arrangements.

After buying an automobile, it is expected that at various intervals the machine will need to be washed, parts repaired or replaced, and attention given to other details, all of which are called maintenance. Peculiarly enough, there are many factories in which new lighting systems have been installed and then entirely neglected, except, perhaps, to replace a burned-out lamp. The lighting system is not very different from the automobile from the standpoint of maintenance, except that when the motor is neglected and refuses to work the whole car is useless, but the lighting system, even though neglected, works faithfully in part at least. Burned-out lamps occur only in spots throughout the plant and do not materially affect the remainder of the lighting system.

But there are other factors which enter into the maintenance of lighting systems that rob the factory of the benefits which good lighting systems contribute. The loss of

Cleaning Schedules for Lighting Fixtures Used Under Different Conditions

Where direct lighting systems are used, i. e., where there are no reflecting or diffusing surfaces concave upward to invite dirt accumulation, the interval of cleaning should be about as follows:

Characteristic of Location	Interval in Days If Units Are Wiped Out*	Interval in Days If Units Are Thoroughly Washed
Very Dirty	3	5
Dirty	7	10
Average	15	20
Clean	30	40

Where open semi-indirect or totally indirect units are used:

Characteristic of Location	Interval in Days If Units Are Wiped Out	Interval in Days If Units Are Thoroughly Washed
Dirty	5	7
Average	10	15
Clean	20	30

*Washing every third or fourth interval assumed.

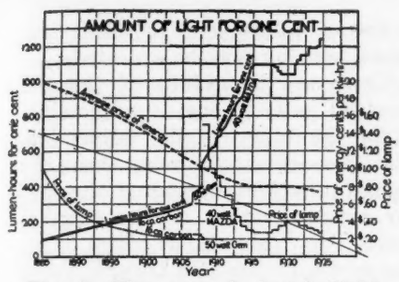


Fig. 2—The cost of electric light has shown a steady decrease since its inception forty years ago.

As may be seen by the solid line the amount of light that can be bought for one cent has increased until it now stands at 1,240 lumen-hours for a 40-watt Mazda lamp. The dash line shows the decrease in the cost of energy, while the dotted line shows the decrease in the cost of lamps.

these benefits constitutes a loss in dollars and cents and, therefore, maintenance can rightfully be considered as part of the cost of lighting.

The fact that better lighting increases production, decreases accidents, spoilage, and labor turnover, indicates that the difference between good lighting and inferior lighting is of more than ordinary importance. It indicates further that the operating executive cannot afford to permit the illumination to be wasted through neglect in keeping the lighting units clean and proper lamps supplied. Experience has shown that one-fourth or even one-half of the light which the illumination system is capable of giving is sometimes wasted because of lack of proper maintenance.

The common neglect in the care of lighting systems can be attributed to the fact that few realize how rapidly and to what extent dirt and dust cut down the output of lighting systems. Fig. 3 shows in graphic form how dust and dirt affect the light output of a reflector. The accumulation of dust upon lighting units is so gradual that it is impossible to discern how materially the illumination is affected from one week to the next. The character of the surroundings will, of course, determine the rapidity with which the lighting is affected. In relatively favorable locations where there is not an excessive amount of smoke and dust, there will be a depreciation of from 10 to 25 per cent in four weeks' time. In excessively dirty locations the depreciation may be as high as 40 per cent in the same length of time. The use of a foot-candle meter will assist in determining when there is need for giving careful attention to the lighting system.

The amount of light that is received at the work is dependent to some extent upon the reflecting power of the walls and ceilings. When dirt and dust have darkened them, less light is reflected and consequently the illumination upon the work is reduced. The lost light due to darkened walls and ceilings can be restored by refinishing them with a flat white or very light, cream colored paint.

Fig. 4 shows the results that were obtained in three investigations that showed failure to observe simple maintenance requirements.

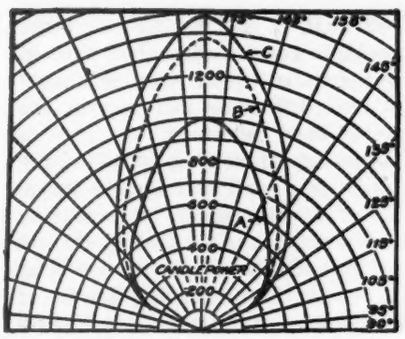


Fig. 3—How dust and dirt affect the light output of a reflector.

Curve *A* shows the light output in candlepower of the reflector when dirty. When merely wiped out the lighting was increased greatly as shown at *B*. After the reflector was thoroughly washed the output was as shown at *C*, which is nearly double that shown at *A*.

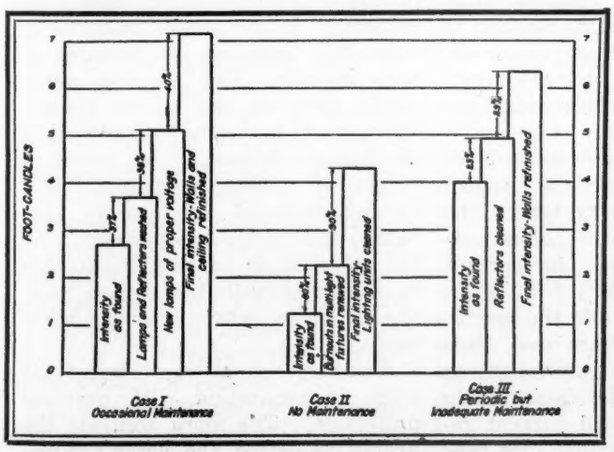
The use of an air brush or paint spray as shown in Fig. 1 will greatly speed up the work of refinishing walls and ceilings.

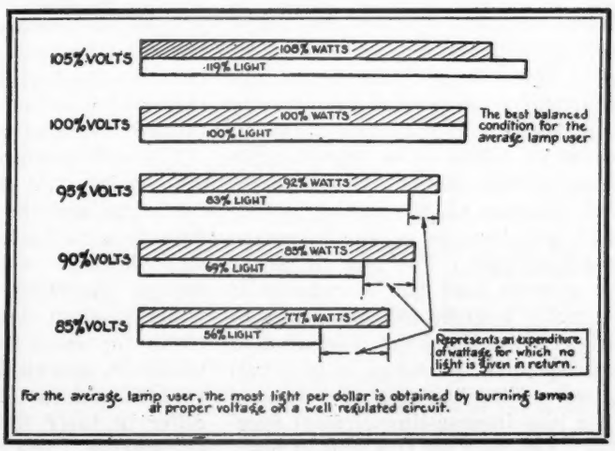
When it is appreciated that the value of light lost through neglect of proper maintenance comprises not only the cost of the energy, but also a loss in efficiency on the part of the workers and a lowered output of the entire plant in general, it is obvious that the slight cost of regular attention to the lighting system is indeed relatively small. It is advisable that a reliable employe be designated to check up regularly on the lighting system according to a definite schedule. Merely wiping out the unit will not always accomplish the desired result. Experience has shown that wiping out a unit results in only about two-thirds the increase in light that is produced by a thorough washing with soap and water. A schedule of inspection periods recommended for different operating conditions is given in the table on page 76.

The cost of maintenance will, of course, vary with the size of the

Figs. 4 and 5—Some of the things to check when attempting to improve your lighting.

Fig. 4 shows the results obtained from three tests made with a foot-candle meter in three different plants. In each case there are given the results obtained after replacing worn out or wrong voltage lamps, and after refinishing walls and ceilings. Fig. 5 shows the effect of burning lamps over and under rated voltage. Over-voltage shortens the lamp life considerably, while operating the lamps at under-voltage decreases the light output as well as lowering the lamp efficiency, although it does increase the lamp life. For the average user the best condition is obtained when the lamps are burned at rated voltage.




105% VOLTS
108% WATTS
119% LIGHT
100% VOLTS
100% WATTS
100% LIGHT
The best balanced condition for the average lamp user
95% VOLTS
92% WATTS
83% LIGHT
90% VOLTS
85% WATTS
69% LIGHT
85% VOLTS
77% WATTS
56% LIGHT
Represents an expenditure of wattage for which no light is given in return.
For the average lamp user, the most light per dollar is obtained by burning lamps at proper voltage on a well regulated circuit.

plant. In a plant that is large enough to require the entire time of one man, the cost of cleaning should not exceed 3 cents per unit in the case of open reflectors.

It is important that lamps of the proper size and voltage be used. Errors usually occur in replacing burned-out lamps. Labeling the reflectors with the proper size of lamp will assist in preventing lamps of the wrong size from being used, while the measuring of the line voltage with a voltmeter and care in ordering lamps to correspond with that voltage will guard against obtaining lamps of improper voltage rating.

Incandescent lamps are rated for a given light output, when operated at the voltage indicated on the label. If the lamp is burned at a higher voltage, a short life will result; if operated at a lower voltage, it will not give the proper amount of light. It is, therefore, important that the voltage rating of the lamp and line correspond, in order that the highest all-around efficiency be obtained. Fig. 5 shows in graphic form the results obtained through the use of overvoltage and undervoltage on Mazda lamps.

In many factories, the units may be mounted at such height that it is somewhat difficult to reach them for cleaning. In such cases, it is well to install the unit in such a way that it can readily be detached. An extra unit already cleaned should be provided to replace the dirty unit which can be removed to the floor for washing. Such an arrangement will be more convenient and safe and will not hinder workmen because of obstructing ladders or lack of light for doing the work.

There is also equipment on the market which disconnects the lighting unit from the power supply and permits the units to be lowered to the floor by means of a rope and pulley. This method is very convenient and is desirable for many locations. It insures frequent and adequate cleaning and at the same time provides absolute safety to the man doing the cleaning, for the man is on the ground instead of on a ladder; also the lighting unit is dead, thereby preventing danger from shock.

Relations Existing Between the Motor and Its Overload Protection

By C. W. KUHN

Development Engineer. The Cutler-Hammer Mfg. Co., Milwaukee, Wis.

PROTECTIVE devices play an important part in motor applications. In these days of fighting to keep down overhead costs, protective devices must prevent shutdowns caused by burned-out or damaged motors due to injurious overloads.

On the other hand, many of the evils of over-motoring in the past, may be attributed to the desire to guard against motor overloads. Obviously, it is not economical to use a motor larger than is actually required by the normal load, merely to make certain that overloads will not occur. It is quite objectionable to use a larger motor than necessary, both because of the initial investment and because of the increased operating cost. The size of motor for a given load can be reduced if the motor is protected under all conditions of load and the overload does not trip until the motor is in actual danger. This has created a demand for a long inverse-time-element overload. The need for this type of overload device has been increased due to the growing practice of throwing squirrel-cage motors across the line. In many cases it is necessary to start considerable load with these motors and it is essential that protection be given during the starting period.

A realization of these conditions has resulted in the development of better motor protective devices, which make it possible to use smaller motors without too frequent tripping of the overload. As heating is the chief limiting factor which determines the load a motor can carry, the new protective devices are of the thermal overload type.

Thermal overload devices may be divided into two types: the thermal fuse type and the relay type. The fuse type is limited to non-adjustable devices. Change in current rating, therefore, occurs in steps which may not always fit the specific motor for which they are used. This would be practically impossible, as various motors of the same rating differ in their full-load current requirements. The thermal fuse type is also at a disadvantage where frequent tripping may be expected.

There are two kinds of thermal overload relays: one is adjustable, while the other is non-adjustable. The non-adjustable relay has the same limitations regarding the motor current rating as the thermal fuse. Any inaccuracies which cause the device to trip at a lower current than that for which it is rated, may lead to the choice of a protective device of higher rating.

The adjustable relays can be divided into three general divisions according to their principle of operation. These divisions are: expansion of metal, bi-metallic, and change of state.

It is well known that the expansion of metals is small per unit of length. Protective devices utilizing this principle, therefore, require considerable multiplication of movement of the actuating element.

The bi-metallic relays utilize the expansion of metal in a somewhat different way. Bi-metallic metal consists of two different metals, welded together. When the temperature of bi-metallic metal is changed, it curves over to that side having the lower co-efficient of expansion. However, bi-metallic metal is not capable of doing much work; hence, friction may be a cause of inaccuracy in this type.

The third division of thermal relay depends upon change of state for its operation and reduces to a minimum the one great cause of error in thermal devices; namely, temperature. These devices are of two general classes: Those which operate due to a change from liquid to gas and those which operate due to a change from solid to liquid.

The class of protective devices depending for their operation on changing of a material from solid to liquid can readily be made very accurate. If the proper material is used, the tripping temperature is very definite. The greatest error would then be due to the heater. This error, however, is inherent in all thermal devices. The manufacturers of resistance material will furnish material for heaters that varies plus or minus 5 per cent. As the variation in current due to this cause varies with the square root, the probable error is really quite small.

Accuracy is a very important point in connection with overload protection. The more accurate the protective device, the closer the mo-

tor application can be made without danger of burnout or of frequent tripping. In other words, an accurate device permits the use of a smaller motor. The temperature to which a motor heats is another very important factor which must be given thought. Tripping temperature should approximate the danger temperature of the motor. Under these conditions, and with motor and starter subject to the same temperatures, the overload device will compensate for varying ambient temperatures. Protective devices whose tripping temperature is too low, will not permit the motor to carry its maximum safe load when placed in high ambient temperatures. On the other hand, if the tripping temperature is too high, they will permit the motor to burn out under these conditions. With low ambient temperature the reverse is true.

Current adjustment over too wide a range by varying the tripping temperature, is very undesirable for the reason that a variation of 50 per cent in the tripping current would mean a variation in temperature rise of over 2 to 1 as this varies as the square of the current.

As thermal protective devices are being widely used at present, it will be of interest to know which type will be the ultimate design.

Here is an instance where

Keeping a Daily Record of All Equipment Failures

has helped to reduce the number of delays and amount of time lost, by making possible a close check on the causes and frequency of breakdowns

By J. H. GALLANT
Canada Cement Co., Ltd., Belleville, Ontario, Canada

IT IS a fact well known to maintenance men, that oftentimes delays occur much more frequently in one department of a plant than in another. It is also true that interruptions occur much more frequently at certain intervals than at others. However, over an extended period of time, and under normal conditions, the averages for time lost and number of delays are fairly constant.

The price of continuous operation, with a minimum of interruptions, is systematic inspection to forestall possible trouble, frequent comparison of present behavior with averages based on records of past performances, and intelligent analysis of the causes of all interruptions. The method of obtaining data now used at Plant No. 5 of the Canada Cement Co., Ltd., takes little time and does not require a very cumbersome system of records.

With over 100 motors in continuous operation, an attendant or shift electrician is, of course, necessary. His duties are to make regular and systematic inspections, as well as handle whatever repairs can be made by one man, in case of trouble. When more help is required to speed up repairs, the shift electrician may call for assistance; a decision is made according to the judgment of the mill foreman. The shift electrician is supplied with a pad of blank forms, one of which is shown in the accompanying illustration,

Form 776

Canada Cement Company, Limited, Plant No. 5

SHIFT ELECTRICIAN'S TROUBLE REPORT

Date ..... Shift No. .....
Drive .....
Down from ..... a.m. p.m. to ..... a.m. p.m.
Reason .....
Repairs done .....
Material used .....
Work still required to complete job, if any .....
Lights .....
Remarks .....
Shift Electrician .....
Shift Foreman .....

and, if there have been no interruptions, he fills in one form at the end of his shift, reporting that all equipment is operating satisfactorily. If interruptions do occur, he fills out one form for each of these, giving all possible information, especially the reason for the delay, and the repairs required. All of the forms which have been filled in during the previous 24 hr. are handed to the Plant Electrician the next morning.

The Plant Electrician enters the data from these reports in a record book, and notes the duration of and reason for each delay. These data are then tabulated at the end of each month, as shown in the accompanying table. Whenever it is found that interruptions on a certain machine occur more frequently than the average shown by past performance, a special investigation is made with the idea of finding the cause and removing it as soon as possible. Before we started this system the same trouble would often recur several times on a machine before it was realized that there was something radically wrong. By this method and record we have succeeded in cutting down the number and duration of delays about 50 per cent within the past year.

A few concrete examples taken from the accompanying table, which gives our records for the past year, illustrate some of the advantages which have resulted. In October, 1924, we found that the number and duration of interruptions for a generator supplying current for our Hum-mer magnetic vibrators were running up above the average of previous months. On investigating, we found that one of the collector rings was worn down eccentric on one side, apparently due to a soft spot. This caused pitting and sparking to such an extent that the machine had to be stopped often for cleaning and sandpapering the rings. When a new ring was put on, the trouble disappeared and did not show up again for over 6 mo. until a ring again had to be replaced.

The cause of another trouble, which showed up in October and

This form is filled in by the electrician in charge at the end of each shift.

One sheet is made out for every delay that occurs; in case there has been no trouble, it is marked O. K. for all equipment. These reports are then turned in to the Plant Electrician who enters the data in a note-book. At the end of the month these reports are tabulated, as shown at the bottom of the following page.

November of 1924, was not so easily found. We were having too many delays caused by trouble with compensator contacts, both on C. G. E. and Westinghouse compensators. The contacts were of apparently the same quality as always supplied, the oil was clean, and the loads apparently no heavier than usual. As there was no apparent reason for this trouble we decided to watch the men starting the machines and found that the majority of them did not know how to start the motors properly. Under the impression that they were making it easy for the machinery, they would slowly pull over the compensator handle, barely making the contacts touch, and, of course, the resulting arcs caused the damage. An educational campaign among the men stopped the trouble.

Another defect which was also quickly brought to our attention by these records was the bearing failures we experienced in March and the beginning of April, 1925. During these months we were shut down for bearing trouble more than twice as frequently as usual; also, this occasionally resulted in burned-out motors.

As we had been down for repairs in February, and all bearings showing any sign of wear had been changed, we should have been comparatively free from bearing troubles. We finally traced this defect to an inferior quality of babbitt with which most of our spare bearings had been babbitted during this period. As a large number of bearings had been changed during the shut-down this helped to increase the trouble. When good babbitt was used on the bearings their average life again became normal.

Again, during the summer months of 1925 we experienced trouble with the relay mechanism on auto-starters. The wrong kind of oil had been used in the dashpots, with the result that the pistons would sometimes stick, preventing the relays from opening on overloads, and at other times open the contacts just enough for them to arc and burn out. At times the pistons held the contacts open by sticking at the top when the handle was thrown to the running position and accordingly the handle would not stay in this position. This source of delays was overcome by using the right kind of oil.

These are only a few of the troubles which were brought to our attention. No doubt all of these troubles would have been traced down in time, but by knowing the average frequency with which they occurred under normal operation, we were enabled to detect and remedy them much more readily than would otherwise have been the case.

Comparative Cost of Welding and Riveting Steel

ARC welding as a method of fabricating structural steel is not a new departure. For quite a few years it has been used in steel ship construction in the assembly of steel ladders, masts, skylights, funnels, deck stanchions, tanks, etc. Barges and floating targets have also been entirely assembled, and pipe lines, gas holders, oil tanks, small bridges and buildings completely constructed by electric arc welding.

An interesting application of arc welding in the erection of a structural steel building was recently made at Eola, Ill., where the Chicago Burlington and Quincy Railroad erected a 60-ft. by 40-ft. one-story, mill-type building, using scrap steel. The character of the welding is shown in the accompanying illustration. An exact duplicate of this building was also constructed by the riveted method. Data furnished by W. T. Krausch, Engineer of Buildings of the railroad company, shows the following costs:

	WELDED	RIVETED
Preparation cost, including material and shop fabrication	$381.71	$1,000.50
Field erection cost	404.49	339.00
	$786.20	$1,339.50

Causes, Number, and Duration of Delays from Electrical Troubles by Months, from September 1, 1924, to August 31, 1925.

CAUSE OF DELAYS	SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER		JANUARY		MARCH		APRIL		MAY		JUNE		JULY		AUGUST	
	No.*	Time*	No.	Time	No.	Time	No.	Time	No.	Time	No.	Time	No.	Time	No.	Time	No.	Time	No.	Time	No.	Time
Motor burned out	5	43:00	3	22:35	2	26:00	1	4:50	2	15:30	2	14:30	2	19:55	4	25:30	3	24:00	2	16:00	1	17:00
Rotor troubles									1	5:00	1	10:00	1	20	1	35	2	35	2	55		
Burned motor terminals	1	45	4	4:10					1	40	1	35										
Change bearings	8	5:55	9	16:15	1	25	6	11:55	9	7:15	16	20:05	7	8:00	4	2:30	3	3:05	7	12:30	7	11:10
Oil rings	1	3:00	2	6:00					1	45												
End caps on ball bearings	3	13:45																				
Other motor troubles	1	30	4	3:00	3	3:05	1	15	3	1:10	2	35	3	1:30	1	20					1	10
Line troubles			1	10	1	20							1	15	1	1:30						
Compensator coils					1	45									1	1:30						
Compensator leads	4	10:15	1	2:00	2	6:00	2	2:50	2	2:00	1	1:00							2	1:45	2	2:25
Compensator relay coils					2	1:00					1	30	1	15	1	30						
Compensator contacts	4	1:40	14	8:15	9	7:30	3	1:10	4	1:15	1	30	2	35	3	1:25	2	40	1	15	1	15
Low voltage release coils	2	3:00	2	45							1	30	1	1:20			2	4:30	2	1:50		
Relay mechanism	4	4:55	3	1:05	2	1:55	2	1:05	7	2:25	2	30	3	55	9	3:25	7	4:25	5	3:05	1	2:55
Release push buttons					1	20							2	35								
Other compensator troubles	1	10					1	30	2	25	1	20	1	25								
Burned switch blades																						
Burned switch terminals					1	1:25			1	40												
Hummer vibrator coils	3	45	4	1:40	3	1:15			4	2:15	2	50	3	1:55	2	45	4	1:05			2	45
Hummer coil circuits			4	1:30	2	40	4	1:30	1	25			1	10			1	1:20			1	15
Other hummer troubles			*1	25	3	1:05			3	1:25					1	1:20	3	1:25	1	1:30		
Hummer generator troubles			*11	11:15	1	05	1	20	1	45	2	20			4	1:50	5	3:10	6	3:55	2	1:00
Fuses	14	3:05	5	1:40	1	15	5	2:10	2	50	2	20	6	2:50	2	30	1	10	4	50	1	15
Total	51	90:45	68	80:45	35	52:05	26	26:35	44	42:45	35	50:35	34	39:00	34	41:40	33	44:25	32	42:35	19	36:10

Plant shut down for repairs during month of February, 1925.

*Vertical colums represent number of delays for the month and their duration in hours and minutes.

The preparation and field erection costs were lowered more than 40 per cent by the use of arc welding instead of riveting for the structural work of this building.

It will be noted that the saving in favor of the arc-welded building lies in the minimum of preparation required—merely the cutting of the steel to the required length. No clip angles, gusset plates or butt straps are necessary, while besides these, the riveted job involved shop details and layout, punching, painting, reaming and shop fabrication. In the riveted structure 27,100 lb. of steel were used, while but 25,619 lb. were used in the welded structure—a reduction of 5½ per cent in favor of the welded type of construction. The saving in steel and reduction in total erection cost in this case resulted in a final saving of 41.3 per cent in favor of arc welding.

While there have been numerous applications of arc welding in the fabrication of structural steel, test data involving welded joints have not been complete. Tests were, therefore, made of welded joints for tensile, shear, static, shock and fatigue strength of such joints, compared to similar joints made by riveting, and to the steel members welded together.

Using ½-in. and ⅜-in. plates beveled at 60 deg. and arc welded to form a butt joint as a section subjected to tensile strength tests, it was found that the joint in the ½-in. plate developed an average tensile strength of 64,400 lb. per sq. in., with an elongation of 4 per cent in a 1-in. section across the weld. The steel in which the joint was made had a tensile strength of between 65,000 and 70,000 lb. per sq. in., and failure in the piece occurred in both base and deposited metal. Welding wire used was hard-drawn, mild steel, having a carbon content of 0.17 per cent and a manganese content of 0.55 per cent.

In the shear test, a similar joint developed 50,550 lb. per sq. in., and when subjected to static tests, a pressure of 40 tons deformed the supporting beams completely, but failed to produce any evidence of failure in the welded joints. In fatigue tests, a riveted and a welded joint of similar design were mounted on a vibratory testing machine and subjected to a vibration or vertical movement of 1/16 in. at the rate of 1,760 complete cycles per minute. After 18 hr. and 20 min. there was hardly a joint in the riveted member which was not thoroughly loosened, the rivets worn, the rivet holes enlarged, and a number of portions broken off the main section. When finally the welded model failed after a long and more severe test, failure occurred in the beams and not in the welded joints. Under a sudden shock of 700 tons administered directly to an arc-welded joint section, the welds did not fail, even though the structural steel members of the section were severely strained and deformed.

The cost of arc welding, in practically all cases, is considerably lower than riveting or other processes. A ⅜-in. fillet weld can be put in for between 15 and 20 cents per linear foot of bead, depending somewhat upon the position of the work. This estimate is based upon labor at $1 an hr., welding wire at 10 cents per lb., and electrical energy at 2 cents per kw-hr.

A. G. BISSELL.
General Engineering Department, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Maintenance of 4,000 Motors

(Continued from page 56)

However, it is noticed that considerably poorer power factor results. For instance, the power factor of the stamping plant is 50 per cent, as compared with the plant average power factor of 75 per cent.

With the exception of the cranes and industrial trucks and tractors, automatic or push button control is used throughout the plant. Here too, the equipment used has been standardized as much as has been possible.

For example, control for squirrel-cage motors is standardized as follows: For motors of 7½ hp. or less, push-button-operated, across-the-line starters are used exclusively; for squirrel-cage motors between 7½-hp. and 30-hp. rating, primary-resistance starters are used exclusively; for squirrel-cage motors larger than 30 hp., only push-button-controlled, automatic compensators are used as control equipment.

For transforming 2,300 volts to 440 volts for power purposes, a standard arrangement of three 300-kva. single-phase transformers, connected delta-delta, is standard in all of the plant substations. Likewise, a 50-kva. single-phase transformer is standard for transforming from 2,300 to 110 volts for lighting.

The same idea of standardization is carried out throughout all of the electrical equipment, wherever it is at all practical. Due to the fact that the Chief Electrician decides upon and specifies what type and make of equipment shall be purchased, standardizing on sizes and types is comparatively easy. The Chief Electrician specifies not only what type and make of motor and control shall be purchased but also he specifies the same for all other electrical equipment including electric portable tools, electric industrial trucks and tractors, travelling cranes, electric hoists, and the like.

Standard schemes of installation are used wherever possible. For example, the lighting distribution boards are made up of a standard arrangement of safety switches mounted on an iron framework. Likewise, the starters for squirrel-cage induction motors are made up in standard forms that include a starter and safety switch arranged on a pipe frame mounting.

INDUSTRIAL ENGINEER
Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories
G. A. VAN BRUNT, *Managing Editor*

Compare Your Methods and Equipment With Those Used in Other Plants

ORGANIZATION schemes and methods of handling work must have a certain amount of flexibility in order to properly meet emergency conditions that arise from time to time. In addition, both organization set-ups and methods require revamping once in a while to adapt them to changed conditions. This is especially true of the maintenance organization of a growing industrial plant. Additions to or changes in equipment and product or processes may so alter conditions that methods and schedules which were entirely adequate when first put into effect are now of comparatively little value.

A good way to judge methods and results is to compare them with those of other men engaged in similar work. Even though operating conditions in different plants vary considerably, it is usually possible to find a basis on which fair comparisons of both methods and results can be made.

This issue of INDUSTRIAL ENGINEER affords a good opportunity to learn the details of the equipment and methods used by the operating and maintenance executives in a large number of industrial plants, and the results that they are obtaining. Careful study of what they have to say may give you reason to feel well satisfied with the manner in which you are handling your work. On the other hand, it may show you where changes in your testing and repair equipment or methods may be made to good advantage. In any event, the time will be well spent.

How Much Trouble Do Rule-of-Thumb Methods Cause You?

IN MANY cases the "rule-of-thumb" and "cut-and-try" methods sometimes used in maintenance and repair work are the underlying cause of many troubles with mechanical equipment. This is sometimes seen in such operations as machining sleeve bearings or in babbitting a worn bearing.

The methods used by the engineer in solving problems arising in the design of machinery, were compared with those used by men who substitute guesswork for analysis, and chance for judgment, in a paper recently presented before the American Institute of Mechanical Engineers by Forrest E. Cardullo, Chief Engineer of the G. A. Gray Co.

In discussing this subject, Mr. Cardullo spoke of the false impressions and large amount of misinformation that exists regarding the design and use of bearings. In his opinion, the best bearing, where possible to apply it, is a perfectly cylindrical sleeve, the hole through the sleeve being larger than the shaft by an amount sufficient to permit an oil film of proper thickness. Such a bearing is quite different from one produced by the very common practice of making a hole the same size as the shaft and then "scraping in" or "fitting" the bearing. A bearing that has been "scraped in," he said, has no room between the shaft and the box for an oil film.

Half-boxes were said to be required in some cases in order to assemble the bearing, but in such instances two half-boxes should be machined to a perfectly cylindrical hole and no shims used. The use of a quarter-box was characterized as a crime and it was stated that a great deal of bearing trouble could be eliminated by the substitution of a properly designed half-box.

In speaking of lubrication and oil grooving, Mr. Cardullo stated that the figure 8's, criss-crosses, and complicated systems of reversed spirals with which many bearings are provided, show that the men who designed them are ignorant on these points.

The improper practices referred to were developed by rule-of-thumb procedure and guesswork. Analysis and application of the correct principles have resulted in important improvements in bearing design. The chances are that the same measures applied to all of your maintenance and repair operations will produce equally fruitful results.

Do You Give the Maintenance Department Full Credit for What It Does?

ONLY too frequently is there a feeling in industrial plants that the maintenance department is a non-producing department. It is so-called because its output does not show up directly among the finished products sold by the plant. This being the case, there is a tendency in some organizations to neglect this department or consider it second when distributing bonuses, salary increases, working equipment, and the like.

This policy is not sound, for the maintenance of the plant is fully as important as any phase of production. Henry Ford says very forcefully, "The first duty of management is to keep the tools in shape. By the tools is meant the entire plant and everything pertaining to it." To go a little further, the main function of the maintenance department is to see that the capital invested in producing facilities is conserved and pays the highest possible rate of interest. This means the equipment must be at all times in condition to produce at full capacity. In the face of this can anyone say that production is more important than maintenance? They are on a par and should be so considered. The output of the maintenance department is a service that is vitally essential to the quantity as well as the quality of production.

Due to the more far-sighted policy of some plant managers and also to the aggressiveness of many maintenance superintendents, this fact is fast becoming recognized in our more progressive plants.

Let the Repair Shop Help to Cut Your Maintenance Costs

MUCH stress has been placed, and rightly so, on the importance of securing the most effective layout of production equipment and eliminating as completely as possible all waste motion and effort on the part of the workman. However, in this effort to obtain maximum output for the time and effort expended, the plant repair shop is often overlooked. In consequence, the arrangement of equipment in many shops has been left to chance and circumstance. Oftentimes, too, facilities are lacking for handling the work in the most efficient manner.

In volume of output and number of employees, the plant repair shop may not rank very high when compared to some of the production departments, but that is no reason why time-saving methods and equipment can not be employed just as effectively there as in any other department. If the use of good equipment and efficient methods make it possible to shorten by a few hours the time required to repair an important motor or other piece of equipment, the saving in production delays on one or two such jobs may go far toward paying the cost of putting the shop on an efficient basis.

A little time spent in studying the equipment, its layout, and the general method of handling the work in your repair shop may show where some worth-while economies that will help to cut maintenance costs, can be easily effected.

Good Equipment Is Worth the Care That It Should Have

SOME industrial operating men, who have adopted the policy of purchasing only standard-quality equipment and supplies, have looked merely at one side of the problem confronting them. They have paid more, generally, to get quality and naturally expect better service from it, but the equipment is not always installed and operated in such manner as to secure this extra measure of service.

There is more to be considered than merely buying the "best on the market." Suitability for the work in hand and care during and after the equipment is installed are just as important. Even the highest-priced automobile will freeze up during winter weather unless some anti-freezing mixture is used in the radiator, or be ruined unless oiled regularly. Also, the best machine or other equipment will have a short life unless it is oiled, cleaned, and cared for regularly.

"Buy the best and forget about it" is a good policy to adopt, providing it is not followed too literally.

Poor Yard Roads Cost as Much as Good Ones

IN MANY lines of industry it is necessary to use yard storage, for example, for the seasoning of castings or lumber, or for storage of flasks, coal, and other materials. In bad weather and particularly during the winter and spring it is often almost impossible to move these materials from storage unless the yard is provided with a roadway which is passable to trucks.

Operating men who will stop to figure out the cost of the waste time and extra men required to help extricate trucks that are stuck in a so-called road, will not find it difficult to convince themselves that a substantial concrete or macadam roadway, or even one made of cinders, if it is kept in shape with a little attention, will much more than pay for itself.

Electric storage battery trucks and cranes, which are commonly used for yard haulage, are capable of carrying considerable overload. However, the task of pulling themselves out of the mud and carrying a load at the same time is certain to be reflected in increased maintenance costs as well as shorter life of the equipment. These items should not be overlooked when determining what poor yard roads cost.

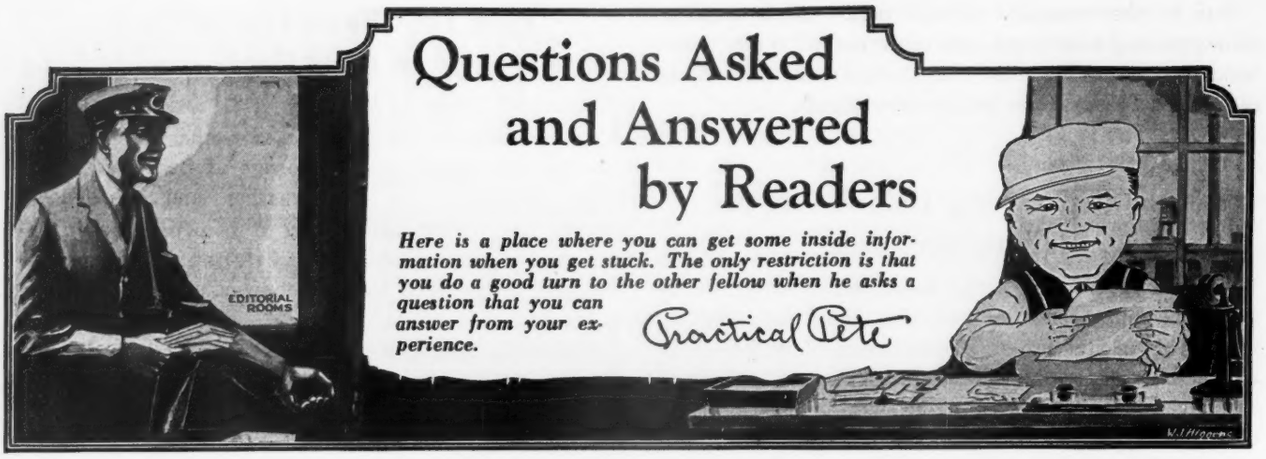
Can You Perform the Prone Pressure Method of Resuscitation?

A FOOLISH question, you may say. Yet is it? We have seen long descriptions and illustrations of how to do it placed in many sub-stations and other places where someone is likely to be hurt by electric shock. Yet when the time came, there was no one that knew just what to do.

The prone pressure method is extremely easy to learn, but is hard to describe. At a recent meeting of an association of practical electrical engineers the method was demonstrated, and although these men are in direct charge of many electrical workmen and it would naturally be assumed that they know all about the method, the amount of interest displayed was astonishing. Many of these men went home with the thought that this life-saving method should actually be demonstrated to all of their men, rather than put on notices scattered around the plant. Then when the emergency comes, someone will know exactly what to do, and how to do it.

In many instances this method has saved the life of persons who were considered to be beyond help. So, no matter what may be the condition of the victim, the method should be applied and kept up for some time.

The prone pressure method is adapted for use in cases of electric shock, asphyxiation by gas, smoke or other fumes, and drowning, and is preferred to other methods, by some authorities. Practical and frequent demonstration by and to your men may be the means of saving many lives. Do it today.



Questions Asked and Answered by Readers

Here is a place where you can get some inside information when you get stuck. The only restriction is that you do a good turn to the other fellow when he asks a question that you can answer from your experience.

Who Can Answer These?

Selecting High-Pressure Bearings.—In one of our manufacturing processes the product is rolled under high pressure. We have always had considerable difficulty with the bearings and as we are going to rebuild the machines are considering installing other types of bearings. I would like to know what types of bearings other operating men favor for paper calendars, rubber mills, and cereal rolls, as I believe our problem is similar. Will some readers from these industries please give me their experience with babbitt (including the type), bronze bushings, ball or roller bearings and the method of lubrication which they have found most satisfactory?
Brooklyn, N. Y. J. A. A.

* * * *

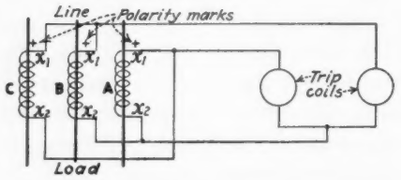
How Much Insulation Should be Put on Cable Splices?—Can some reader tell me how many layers of varnished cambric tape should be used for insulating the splices of lead-sheath power cables of the following voltages: 110, 220, 440, 550, 4,000 and 20,000 volts. Do you think some other kind of tape preferable for this work? I shall be grateful for any information that readers can give me regarding the amount of insulation that should be used when splicing cables of the above voltages, and also for any other information or suggestions as to the best method of handling it.
Toledo, Ohio. S. J. M.

* * * *

Is Hard-Drawn or Cast Copper the Better Material for Commutators?—I would like to find out the difference in operating characteristics, if any, between commutators made from hard-drawn copper and from cast copper. In the advertising literature of many of the large manufacturers of motors and generators, commutators are frequently described as being made of hard-drawn copper. Some repair shops furnish commutators made from cast copper. Which material wears the longer? Which material will polish better under the brushes? Does the sand in the cast copper cause eating away of the mica segments between the bars? Would the use of cast copper segments cause excessive heating of a generator or motor? I shall appreciate any information or comments that readers can give me regarding their experience with either type of material.
Cleveland Heights, Ohio. C. B. K.

* * * *

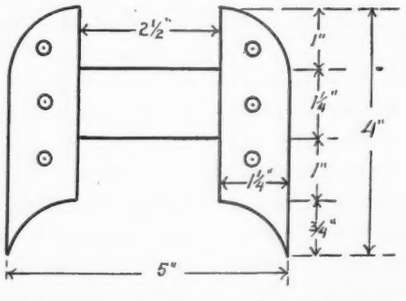
Is This Relay Connection Scheme Correct?—I have a 300-hp., three-phase, 60-cycle induction motor that is star-connected to a 4,000-volt, four-wire, three-phase, power supply. Three 75-to-5 ratio current transformers are connected as shown in the diagram to the two trip coils on the circuit breaker for this motor. I believe this connection scheme is incorrect. It looks like a delta connection, but has one current transformer reversed. I think that a "Z" connection of current transformers should be used, but that is not the case here. Will some reader show me how these current transformers should be connected to



insure proper protection of the motor, and also tell me the proper current setting of the trip-coil plunger, so as to trip at 125 per cent load on the motor? Full-load rating of the motor is 39 amp. The trip coils referred to are solenoids located on the faceplate of the circuit breaker and have plungers operating directly on its trip latch.
Waukegan, Ill. S. D. H.

* * * *

Winding Data for Growler.—I wish to build a growler of the dimensions shown in the accompanying diagram, for use in testing armatures in our shop. It is my intention to wind this growler with No. 12 double-cotton-covered magnet wire and I wish some reader would tell me the number of turns of wire to use and also the depth of laminations required. I want to use this growler on 110-volt alter-



nating current. Any information that readers can give me about making up this growler will be greatly appreciated.
Hattiesburg, Miss. J. M. M.

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Determining Number of Poles in Stator by Use of Compass.—(1) Can some reader give me a simple method of determining the number of poles in two- and three-phase stators when the nameplate is missing? That is, can I pass direct current from dry cells or other source through the winding and use a compass to locate the poles? Or will it be necessary to trace out the winding? How should I go about tracing out a winding to find the number of poles? (2) Why does the terminal on the positive pole of a storage battery corrode, while the negative terminal does not? I shall appreciate your help on these questions.
Worcester, Mass. R. S. T.

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Paralleling Open-Delta-Connected Transformer Bank With Closed-Delta Bank.—I would like to obtain the experience of some of our readers in regard to parallel operation of an open-delta-connected bank of transformers with one or more closed-delta-connected banks of transformers. Under what conditions is such operation possible? How does the load divide between the several banks of transformers? How is the capacity affected of both the open-delta bank as well as the closed-delta bank? If we have two banks of closed-delta-connected transformers operating in parallel on both the high- and low-tension sides, will these two banks of transformers continue to operate satisfactorily and divide their load in accordance with their capacity, if one transformer is cut out of one bank so as to make an open delta connection? In this particular case, all of the transformers are of the same size, voltage, ratio, reactance, and were made by the same manufacturer.
Wilmington, Del. H. E. H.

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Answers Received To Questions Asked

Ramp for Industrial Truck.—The basement floor of one of our buildings is 4 ft. below the grade level. We are planning on installing an electric storage battery truck for handling heavy material out of this basement and from the yard up to the first floor. What grade should be given to the incline or ramp? Would it be advisable to roughen or ridge the surface of the concrete to give the truck better footing? Part of the ramp will be outside, and exposed to the weather.
Peoria, Ill. S. L. G.

In reply to S. L. G.'s inquiry, he will find that the longer and more gradual he can make the ramp the easier it will be on the battery and the truck. Standard makes of trucks can be equipped with batteries large enough to handle any reasonable load on any reasonable grade. My experience has been that even where a truck is equipped with a battery somewhat larger than standard rating, a grade of 1 in 8 is about the operating limit. The truck labors on this grade with its rated load unless the battery is fresh from charging.

I do not know what figure truck manufacturers use in estimating tractive effort on level floors, but after taking into consideration the heavy going due to unavoidable irregularities

a value of 20 per cent of the load, which is often used in similar work, would probably be a fair upper value. Thus a grade of 12.5 per cent on top of the regular tractive effort would increase the effort required of the motor 62.5 per cent above that for hauling on the level. I would suggest that S. L. G. make his ramp 50 ft. long, if possible, which would give a grade of 1 in 12½ or 8 per cent, as it will be much easier on the truck batteries.

For the usual rubber-tired truck wheels, a plain concrete surface, finished with a wooden float but not troweled, will give ample tractive contact, even if wet, and is much better than any form of ridges or grooves, which only bump and impede the truck. It is a good idea on a runway such as this to use an integral floor hardener, such as some of the powdered-iron preparations, as they greatly reduce the wear of the surface.

In building a ramp the grade should not start and finish abruptly, but should gradually curve from the level floor to the full slope or incline of the ramp.

This transition at the top and bottom may well be 6 to 8 ft. This is especially important if the grade is steep, because where the transition is short and the truck under-clearance small it may rub or become stranded when going over the top. Also the truck would tend to bump at the bottom of a sharp transition. Steering rods are usually the lowest part under the frame and should be inspected occasionally to see whether they are scraping as otherwise they may break and cause a bad wreck.

H. D. FISHER.
Plant Engineer,
New Haven Pulp & Board Co.,
New Haven, Conn.

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Will Two A.C. Motors Operate Satisfactorily in Parallel?—We have a turntable driven by a variable-speed, slip-ring a.c. motor. This motor is too small and rather than incur the expense of buying one motor that is large enough to handle this job, we are considering buying another motor, a duplicate of the present one, and connecting it directly to the table, so that the two motors will both drive the table in parallel. Will the motors operate satisfactorily in parallel? Can we operate both motors from the same secondary resistance and controller, or should we use two drum controllers and two independent resistances? I will greatly appreciate any information and experiences that other readers can give me on this subject.
Omaha, Neb. G. C. B.

In reply to the question asked by G. C. B., we have two, three-phase, slip-ring, Allis-Chalmers motors, one rated at 400 hp. and the other at 200 hp., running in parallel on a copper rod mill drive. These two motors are direct-connected to opposite ends of the same shaft.

These motors are both fed from the same oil switch; one trip coil with current transformer being used for overload protection for the 400-hp. motor and the other trip coil for the 200-hp. motor.

Each of the motors also has a double-pole, push-button-operated, magnetic contactor. Red indicating lamps are installed on the panel with the push buttons, informing the operator when the contactor for either motor is closed.

The machine is normally started without load and can be started only by means of the 400-hp. motor; this motor has a secondary controller and resistance of the usual type. We have added an interlocking contact at the bottom of the controller which makes contact on the last point and is connected in the push-button circuit to the contactor coil of the smaller or 200-hp. motor.

Hence, only when the drive is up to speed, can the second motor be started. This is accomplished simply by pushing its start button. The rings of this motor are permanently short-circuited by means of German silver strips connected across the brush holders. The purpose of these strips is to insert a low resistance in the secondary of this motor, and the length of the strips was adjusted by trial until the motor was carrying its proportionate share of the load. In case the load is light either motor may be tripped off the line and the load carried by the other.

In the case of the turntable mentioned, since the motors are variable speed and both will be required at starting, I believe the simplest method would be to provide a separate secondary resistance and controller for each motor, gearing the controllers together so that they will operate together as a unit.

It would be possible to parallel the motor secondaries and use one resistance if the rotors have the same voltage characteristics and are phased out properly when connected. In this case a resistor of greater carrying capacity would be required. However, the present controller might serve, if of generous design.

The second motor will not need to be as large as the original motor unless twice the horsepower of the first motor is required.

W. W. LANKTON.
Ass't. Electrical Engineer,
Detroit Copper & Brass Rolling Mills,
Detroit, Mich.

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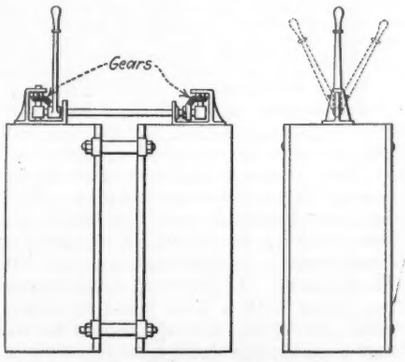
Replying to G. C. B.'s inquiry, it is possible and practicable to operate two motors in parallel to drive the turntable.

The second motor should be an exact duplicate of the first motor in full-load speed and secondary characteristics. The drive pinion on both motor shafts should have the same number of teeth and pitch.



Method of mechanically connecting two controllers for wound rotor motors driving same shaft so as to start them simultaneously.

One drum and a separate secondary resistor are required for each motor The drums should be mechanically interlocked by means of a duplex drive arranged as shown in the accompanying diagram. The drums should be of the same design and the secondary resistors laid out for the same load and speed reduction. Drums designed to operate motors in parallel are built by manufacturers of electric controlling devices.

E. H. LAABS.
Engineering Department,
The Cutler-Hammer Mfg. Co.,
Milwaukee, Wis.

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Regarding the question asked by G. C. B. two slip-ring motors can be made to operate satisfactorily when connected to the same load. To carry out the scheme successfully, the rotors should have independent rheostats with a single control lever. As this lever is moved, it must cut in or cut out resistance to the same amount in the rotor of each circuit. Motors in this case must have the same electrical characteristics. The primary or stator windings are connected in parallel and are switched or reversed by a single switching mechanism.

There are installations where two slip-ring motors controlled as described above, are in use on railroad turntables that are successfully giving the desired balanced drive. Should G. C. B. so desire, we could probably arrange to have him correspond directly with the men who have charge of installations such as those that have just been mentioned so as to obtain further information.

W. S. PFEIFER.
Allen-Bradley Co.,
Asst. Chief Engineer,
Milwaukee, Wis.

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In reply to G. C. B. I would say that theoretically it is poor practice to operate two slip-ring induction motors in parallel; that is, with their secondaries using the same secondary resistance. There probably will always be some circulating currents between the two machines.

Two-motor controllers that are designed for such work as this, have a double-cylinder development which keeps the resistors of the two machines entirely separate. On the first point of such a controller the two motors are simultaneously thrown across the line with resistance in the secondary circuit. On succeeding points of the controller, blocks of resistance are simultaneously cut out of the secondary.

It is the writer's personal opinion that fairly satisfactory results can be obtained using duplicate motors in parallel on a single motor controller and having the same speed, horsepower, etc., and, of course, built by the same manufacturer, particularly if the service is intermittent as is the case with motors driving a turn-table.

Before deciding on using two motors operating in parallel it would be advantageous to compare the cost of the additional smaller motor with the cost of a motor large enough to carry the entire load. The additional cost of the

larger motor will, of course, be offset somewhat by whatever could be secured from the sale of the motor that it replaces. G. C. B. does not state the size of the motor he has nor how much more power is required. If a 20-hp. motor is now used and a second motor is required it must also be rated 20 hp., for successful parallel operation on a single motor controller. If a 20-hp. motor is able to handle the load at present I doubt whether a 40-hp. motor is needed; possibly a 30-hp. motor would be large enough. An investigation of the difference in price between a 20-hp. motor and a 30-hp. motor will probably show that the increased cost of the larger motor will not be so great as expected. The chances are that the controller now in use will be large enough to handle the larger motor.

The starting resistor will doubtless have to be replaced and if so, care should be taken that the grids have ample mechanical strength to withstand any breakage caused by the jar of the locomotive when it comes onto the turntable. Also, using one motor instead of two will reduce the upkeep and make a better job in every way.

R. F. EMERSON.
Industrial Engineering Dept.,
General Electric Co.,
Schenectady, N. Y.

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In answer to G. C. B.'s question, I would say that two wound-rotor induction motors may be operated in parallel.

If the motors are permanently connected together mechanically a single primary and a single secondary controller may be used for starting both motors.

In making the permanent mechanical connection between the two rotors care should be taken to phase out the rotors to insure proper phase relations.

Hopewell, Va. R. M. BUSH.

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With reference to G. C. B.'s question, I believe that it will be satisfactory to operate the two slip-ring motors in parallel if the new motor is a duplicate of the present motor. It will be necessary, however, to have an independent drum controller and secondary resistance for each motor as they cannot be operated satisfactorily with a single drum controller and resistance. If the two drum controllers are mounted side by side and operated simultaneously, no difficulty should be experienced in their operation, but it will be necessary to make frequent inspections to be certain that the primary fuses of each motor circuit are intact. It would be better of course, on account of the added complications, to use a single motor of the proper rating.

East Cleveland, Ohio. L. J. JOHNSON.

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Answering G. C. B.'s question as to operating two slip-ring motors in parallel, I would say that this can be done successfully by using one secondary resistance and controller twice the size of the one now in use. Two separate controllers and resistances could be used but would have to be moved together or one motor would take more than its share of the load. Therefore, one control would be far better. The motors should be of the same make and type, as some motors take more current on starting and also have more torque.

The writer has worked this out a number of times on machines requiring two motors, especially flour milling machinery. Of course, the rotors of the two motors must be properly phased out before the rotors are connected in parallel.

Williamsport, Pa. R. M. KONKLE.

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In answer to G. C. B., on operating two alternating-current motors in parallel, I assume that he has in mind two polyphase, variable-speed, induction motors.

It is practicable to have two motors coupled to a single load. Both motors must be started together. One way to do this is to excite the stators, then with two separate drum controllers and resistances start the motors. The shafts or handles of each controller should be coupled together in a manner similar to a double controller. Hence both motors are started together, if both resistances are alike. In this manner both motors have the same acceleration and each motor will carry one-half of the total load.

San Francisco, Calif. P. P. SCRIBANTE.

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In reply to G. C. B., I have had unusually good success in operating two slip-ring induction motors, connected in parallel, from the same controller and resistance, the motors being the same size, make, etc. We made tests to ascertain the characteristics of each motor. After it was found that the motors were almost identical in every way, they were connected together by means of a flexible coupling, the controller and resistance being approximately doubled in capacity for this duty.

Although this arrangement was satisfactory, I would recommend that a motor, having the necessary capacity, be purchased as it will give better efficiency. PHIL D. COMER.

San Bernardino, Calif.

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Method of Drilling Holes Through Plate Glass.—I have to drill some holes in plate glass ¼ in. thick and wish some of our readers would tell me the best way of doing this. I have tried various methods but without much success and shall appreciate your suggestions.

Little Rock, Ark. M. J. J.

In answer to M. J. J., I have used the following method for drilling holes in glass with very good results.

The necessary tools are a small drill press, a piece of copper tubing with an outside diameter equal to the size of the hole to be bored, a quantity of powdered carborundum and a little turpentine. A block of wood about 1 in. thick with a hole bored through it the size of the tubing, should be used as a guide for drilling.

The copper tubing must be firmly held on the spindle of the drill press. In order to do this, heat one end of the tubing and drive it over the spindle while hot. The tubing should revolve at 50 or 60 r.p.m. and the carborundum moistened with turpentine should be fed into a hole cut in the side of the tubing. The pressure must be slight, and the tube should be raised frequently to allow fresh cutting power to work beneath it.

In cutting plate glass by this method, it will be necessary to grind off the cutting end of the tubing once or twice, in order to obtain the full thickness of the wall. With this method about an hour is required to cut through ⅜-in. plate glass.

Oakland, Cal. ROBERT BUCKETT.

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Referring to the question by M. J. J., gum or glass camphor will make the process of drilling glass almost as simple as drilling hard wood.

Glass camphor may be obtained at almost any hardware or paint store. An ordinary drill bit, such as is used for drilling metal, may be employed and the glass camphor should be applied in small drops at the point of drilling. Care must be taken not to apply too much pressure while drilling, especially when the hole is nearly through. PHIL D. COMER.

San Bernardino, Calif.

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Referring to the inquiry by M. J. J. about drilling holes in plate glass, a brass tube made be used with good results for boring large holes. The brass tube should be held in a drill press chuck and guided through a hole in a cork cemented to the glass being fed with powdered emery, and water should be applied to the lower end of the tube.

For drilling smaller holes a flat drill, similarly centered and lubricated with either turpentine or an alcoholic solution of camphor will work satisfactorily. This drill should be at least of file hardness to give good results.

Most glass can be filed the same as cast iron if the file is moistened sufficiently with one of the above solutions. H. D. FISHER.

Plant Engineer,
New Haven Pulp & Board Co.,
New Haven, Conn.

* * * *

In answering M. J. J.'s question I will assume that he has unlimited patience; otherwise there is but one answer, and that is to have someone else drill the glass for him.

An ordinary drill can also be used if it is dipped in muriatic acid of medium strength to keep it in glass-cutting condition. Quite naturally, this means the end of that drill's usefulness.

Turpentine applied to the glass is very beneficial regardless of the means of cutting, and when carborundum is mixed with turpentine and applied to the glass a simple drill can be used.

This drill can be made by breaking off the point of a three-cornered file to a 2½-in. or 3-in. length. It should be used in a hand drill at a good rate of speed and not much pressure.

Extreme care must be taken when the hole is nearly through, for the

glass is then quite weak and it is at this point that breaking usually occurs, if too much pressure is applied, or by allowing the drill excessive freedom. Naturally, the glass must be securely fastened to a base while it is being drilled. Do not economize on turpentine, use a fair speed and decrease the pressure as the drilling progresses. These precautions together with a whole lot of patience, will insure satisfactory results.

Newark, N. J. EDWARD JAMES.

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In answer to M. J. J., any hard steel tool will cut glass fairly easily when moistened with camphor dissolved in turpentine. To support the tool a drill bow or even the hand alone may be used. A round hole may be readily enlarged with a round file moistened with turpentine and camphor. Flat window glass can be sawed with an ordinary watch spring saw and even the most brittle glass can be worked without difficulty by the use of cutting tools kept constantly moist with the above solution. MARTIN G. LANE.

Electrical Engineer,
Climax Molybdenum Co.,
Climax, Col.

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Replying to M. J. J., I have found the following method to be very useful indeed.

A tool for this purpose is made from a mild steel rod of suitable length, with an outside diameter approximately 0.012 in. smaller than the actual size of the hole required. The cutting end is hollowed out with a drill, leaving a wall thickness of $\frac{1}{32}$ in. The other end of the rod is held in a hand or breast drill.

A flat surface is required, such as a drawing table or desk table padded with newspapers. A piece of paper the size of the glass is marked out for the holes and the glass is laid over the paper.

A wooden block with a hole the size of the tool is placed on top of the glass and a weight, preferably one with a hole in it, is put on the wood to keep it from shifting out of place. Carborundum and turpentine are poured on the glass through the hole in the wood, and when the tool is placed in the hand drill and rotated on this abrasive, it will bore a clean hole in approximately 20 min.

If it is desired to have a smooth edge on both sides of the glass, just reverse the sides when the hole is bored halfway.

If the piece of paper with the locations of the holes is the exact size of the glass, it will help to locate them accurately when the glass is reversed. Carborundum and turpentine should be added from time to time as the glass is worn away. After the hole is started and is about $\frac{1}{32}$ in. deep, the wood may be removed, which will make it easier to feed the tool with carborundum and turpentine.

If the glass is small and a drill press is available similar results may be obtained by running the tool at slow speed and feeding it lightly, but often, with carborundum and turpentine.

Montreal, Que., Can. J. C. BRAY.

Stopping Breakage of Gears.—On each battery of furnaces in our refinery there is a 7½-hp., 1,800-r.p.m., motor driving a device that clears the coke from the furnace. The motor is connected by a roller chain to a shaft driving a pinion meshing with a large double gear that drives the device. This device is subjected to very unusual loads at times, especially when it is about time for the furnace to be rebuilt. These loads are so heavy and come on so suddenly that the teeth are often broken off the bevel gear, which is made of cast iron. As it is rather expensive to replace these gears, I am wondering if our readers can suggest some device that I could put on this drive to disconnect it when the load becomes too great. Would a coupling having shear pins do the trick? How could I make such a coupling?

Tulsa, Okla. L. A. N.

In reply to L. A. N., a motor speed of 1,800 r.p.m. is, in my estimation, too high for the use of a roller chain. I would recommend the use of a silent chain, which is better adapted to regular motor drives. Also, I believe that a shearing pin sprocket could be used to good advantage in your case.

Ithaca, N. Y. A. B. WRAY.
Morse Chain Co.,

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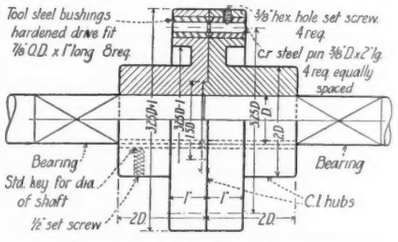
Answering L. A. N., if the suddenly applied heavy loads do not stall the motor, it would appear that the gears are not of the proper design. Cast-iron gears repeatedly subjected to sudden, heavy loads will crystallize with the result that breakage occurs at normal or even light loads. I suggest making the bevel gears of steel castings.



The dimensions of this shearing-pin hub are given in terms of the diameter of the shaft on which it will be mounted.

A shearing-pin hub can be used to advantage in places where the machine elements are subjected to severe heavy loads.

In the absence of data regarding the speeds of the shafts, gear and chain ratios, diameter of shafts and so on, it is difficult to design the proper shearing pin device. However, the accompanying sketch gives the proportions in terms of the diameter of the shaft on which it is to be mounted. The tool steel bushings are not essential as far as the functioning of the device is concerned, but are of value when removing the sheared pins, as they protect the hole from being torn or wedged. The shearing pins are grooved in the middle to a reduced area depending upon the maximum torque required to operate the shearing device.

Since there is not sufficient information given to calculate the torque at the point where the shearing-hub device could be located the size of the groove can be obtained by trial or actual experience. The shearing-pin hub should be supported by a pillow block bearing at each side.

Engineering Dept., E. H. LAABS.
Cutler-Hammer Mfg. Co.,
Milwaukee, Wis.

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Why Does One Brush Arc on This Commutator?—I have been testing some series-wound motors rated at 1/60 hp. These run 1,600 r.p.m. under load and take about 0.4 amp. Speed is governed by a three-ball friction governor. With the governor released, the speed is 7,000 r.p.m., at no load. The motor is connected in series with 180 ohms resistance across a 110-volt a.c. line. thereby impressing about 38 volts across the armature.

We have considerable trouble with the brushes arcing and cutting the commutator. This makes the speed very irregular; so we are trying to improve the commutation. Offsetting the brushes so that they do not track increases the trouble. One brush will arc badly, while the other does not and leaves a very little carbon deposit on the commutator.

The commutator has 36 segments and is 1¼ in. in diameter. We have used several grades of brushes, but the best lasted only 368 hr. If anyone can explain this trouble or help me improve the commutation, I shall appreciate it.

Camden, N. J. L. G. J.

In answer to L. G. J., I believe that the chief cause of sparking in his case is an unbalanced armature, or it become unbalanced after the governor is attached or connected to the armature.

Another cause may be that the commutator is not running true with the bearings. If the commutator is the slightest fraction of an inch out of line with the shaft, it will cause sparking. To remedy this, turn the commutator in a lathe on centers. Be sure to clean the center, or recut the center in the armature, first.

Do not use a brush which is too soft; a good medium carbon brush will be necessary. The springs must have the proper tension.

The above suggestions are made on the assumption that the armature has been tested with a millivoltmeter for open circuits and short-circuits, and that the field is also free from shorts or grounds.

Los Angeles, Calif. H. A. NIELSEN.

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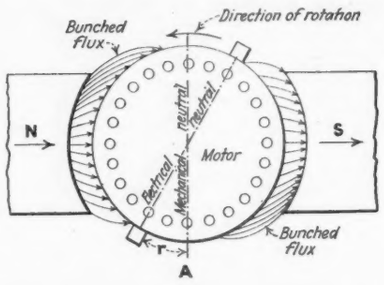
With reference to the question asked by L. G. J., I would say that series motors, which do not have a compensating winding, have the brushes shifted from the mechanical neutral against the direction of rotation, thus bringing them to the electrical neutral. To obtain this result the brushes are moved through the angle r, as shown in A of the accompanying illustration. Due to the armature reaction, the field flux will be stronger (bunched) on one tip of the pole than on the other, as shown.

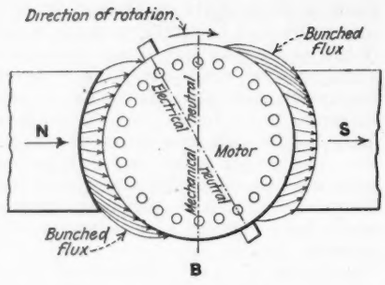
If the direction of rotation is changed by either reversing the armature or field leads, the field flux will bunch on the other pole tip, thus changing the electrical neutral. Unless the brushes are shifted from the mechanical neutral in the opposite direction, as shown in diagram B, the brushes will not be on the electrical neutral. Therefore, sparking will be prevalent, but may be confined to only one brush.

L. G. J.'s trouble may be due to the brush-holder and not to the internal connection of the motor, because the

This shows the relation between the electrical and mechanical neutrals for a series motor not having a compensating winding.

Diagram *A* shows the direction in which the brushes must be shifted for counter-clockwise rotation of the motor, while diagram *B* shows the relation for the opposite direction of rotation.





trouble is confined to one brush. Furthermore, the brush life that he is obtaining, is too short. This is an indication of low brush pressure causing the brush and the commutator face to burn away very rapidly. Rapid brush wear cannot be laid to too heavy brush pressure.

If the brush-holder is of the cartridge type, the coil spring should be carefully inspected. Sometimes it will catch on the inside of the brush-holder and will not apply sufficient pressure to the brush. Also, the spring may be too weak to apply the necessary pressure. In either case the spring tension should be carefully tested by lifting the brush from the commutator face.

Regardless of the type of brush-holder, it would be advisable to inspect the brush carefully to see that it works freely in the box and that the pressure on the brush is sufficient to give a good contact. Very often foreign matter will be found adhering to the inside of the box, thus preventing free travel of the brush.

From the data furnished I am assuming that the brushes are movable. Therefore, another suggestion may throw a little more light on the subject. Due to the fact that sparking is confined to one brush, and if the brush is found to work freely in the box with the proper brush pressure, the next step would be to check the brush spacing. If it is a two-pole motor, the brushes should span one-half of the commutator bars. The brush which does not spark is probably properly located in the commutating zone, while the brush which sparks may be shifted away from the commutating zone. Therefore, it would be short-circuiting bars that are connected to coils whose potential is not zero, thereby causing the brush to draw an arc when the bars pass out from under it. If this is the case, move the brush-holder holding the brush which does the sparking, in either direction until the sparking decreases.

The explanation of the increase in sparking with an increase in load is as follows:

(*A*) When the brush tension is low, or if the brush is sticking in the brush box, the increased current through a poor brush contact will increase the sparking. A simple test is to apply additional pressure to the brush. If the sparking stops, the cause is evident.

(*B*) If the brush is off the commutating zone, the increased armature current will cause an increase in the reactance voltage, which will in turn cause an increase in the short-circuited current which must be broken when the commutator bars pass from under the brush.

J. M. ZIMMERMAN.
Renewal Parts Engineer,
Westinghouse Electric & Mfg. Co.,
Pittsburgh, Pa.

Method of Turning Commutators—I would like some pointers from readers as to the best way of turning commutators in a lathe. What size and shape of cutting tool should I use for the roughing cuts? Will this same tool be satisfactory for the finishing cuts? What is the best cutting speed? Would you recommend using sandpaper to give a final polish to the commutator or do you depend on the lathe tool to give the final polish? I shall appreciate any other details about turning commutators that readers can give me.
Hammond, Ind. H. H.

Answering the question asked by H. H., I use the same kind of tool as for turning shafting. Run the armature as near to operating speed as possible, taking light cuts until the commutator is true. Then sandpaper the commutator with No. 00 sandpaper, so that all tool marks are removed.

Grind a tool to a "V" point of the same thickness as the mica between segments. Now undercut the mica by moving the carriage with the pointed tool by hand and rotating the armature one segment at a time. After completing the undercutting, sandpaper the commutator again to remove all burrs. Finally blow out all traces of sand and copper cuttings. This treatment will give excellent results.

E. N. DILLARD.
Chief Electrician,
Booth-Kelly Co.,
Springfield, Ore.

* * * *

H. H. will find that an undercut commutator should be turned at a fairly high peripheral speed, for a slow speed will cause the copper to drag over the slots.

In regard to the tool to use, I prefer a sharp, diamond-pointed tool, with one side (the side away from the cutting side) ground at an angle of 10 to 15 deg. This tool is used for the rough cuts. For the finish cut I prefer a slightly blunt nose on the cutting tool, but it should, nevertheless, be sharp.

By using a slightly blunt tool for the finish cut it will make a smooth cut even if the feed does not function in time with the revolutions of the armature.

After a good finishing cut, it should not be necessary to use a file, but as some mica and some copper is harder than others it may at times be necessary to use a file and also sandpaper. When using these, back up on the tailstock so as to let the armature turn very freely. Run the armature at a very high speed and use the file sparingly as a file or sandpaper will wear away the copper more rapidly than the mica, which will result in high mica unless the commutator is undercut.

It is also essential that the point of the tool be as high or even a trifle higher than the center of the commutator, for with this adjustment it will cut better, and you do not run chances of digging into the commutator. You can always tell if the tool is cutting properly by the shape of the chips. If they curl up and look smooth you can be quite satisfied that the commutator will have a nice finish. If the speed of turning is too slow, I find that the mica will not cut even with the copper, as may be determined by running your finger nail over the commutator.

In regard to the size of tool to use, I find that it makes very little difference as long as it is ground to the right taper. I may add that the tool should have a slight taper on top away from the cutting side, so that the chips will drop off about ¼ in. from the commutator. Only the top or cutting edge will touch the commutator.

NICHOLAS J. WEISS.
West New York, N. Y.

* * * *

The selection of a commutator turning tool is of less importance than many other item affecting this line of work, as the choice in most cases depends upon the machinist doing the work for most machinists have their favorite tools for different lines of work irrespective of best practice. The most important part is in setting the tool for a minimum cut with respect to the high points, which are surprisingly high in many cases.

Before any cutting is done it is a pretty good idea to protect the risers and the inside of the armature from the resulting dust and chips. About the simplest manner in which this can be accomplished is to tie a piece of cloth about the commutator as close to the risers as is possible, after which it should be stretched over the top of the coils and tied again, being tightened further after it has been tied in place on top of the coils.

Outside of care in the use of the tool and the taking of medium cuts, there is little to be said regarding the actual turning of the job. With manufacturers this generally resolves itself into two distinct processes, a rough cut followed by certain manufacturing operations and then by the finishing cut.

As to speed I have found that in turning a commutator without removing it from the generator a speed of 100 r.p.m. is satisfactory. In grinding a commutator, however, it is necessary to run it at normal speed with the grinding wheel running in the opposite direction. If the commutator on an

adjustable-speed motor is being ground, always grind it at its highest rated speed.

As to the polish I will say that I have seen a number of jobs turned out by using a roughing cut followed by sandpaper for polishing but it is the practice of a large manufacturer who is building up an enviable reputation to take two different cuts, slot the commutator and polish while running at the highest rated speed of the armature. This procedure gives an armature as nearly perfect as it can be produced.

However, for ordinary repair work a diamond-pointed tool with No. 00 sandpaper, used with consideration will produce very satisfactory results.

Newark, N. J. EDWARD JAMES.

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In reply to the question asked by H. H., I would say that we have found that any experienced machinist in our shop does very satisfactory work at turning a commutator. As to the speed of the lathe would say that this is not an important feature of the operation, but using a good arbor that fits well and is well centered so that the commutator revolves true, is quite important. We use a very sharp tool of no particular design and feed it very lightly, going over the commutator several times and feeding still lighter on the finish. We then polish with fine sandpaper using a slow lathe speed.

Chief Electrician, A. C. BARKER.
W. S. Libbey Co.,
Lewiston, Me.

* * * *

Answering H. H., the cutting tool should be set at an angle of about 45 deg. and slightly above center. Use a sharp diamond-shape tool and have the commutator turning rapidly. Take a fine cut and when all of the flat places are gone, take an extra fine cut. Then file with a bastard file so as to remove the tool marks on the commutator.

Before the polishing process is started the commutator must be slotted, so as to remove high mica. Then go over the whole commutator to see if there are any burrs that will short some of the segments.

Next take No. 0 sandpaper to start polishing the commutator and give the final polish by using No. 00 sandpaper with a little oil on it.

HARRY J. ACHEE.
Chief City Electrician,
Woodward, Okla.

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In turning commutators, I use a diamond-pointed tool, that is ground to about 50 or 55 deg. and rounded up with an oil stone. There should be about 12 or 15 deg. clearance. The ⅜-in. square tool steel can be ground properly and used for this purpose.

The tool must always be set at the center of the commutator, or above, because copper is very tough and will drag. The tool will also drag if the clearance is not sufficient. It is possible to cut copper at almost any reasonable speed, but if too slow a speed is used good results will not be had.

It is good practice to slightly round the ends of the bars, and this can also be done with a fine mill file. After the commutator is turned I use a mill file, giving the file strokes a rolling motion.

Some mechanics use oil with sandpaper for polishing, but this is not good practice, as any electrical manufacturer will tell you. I use sandpaper after filing, but no oil. After the sandpaper has been applied, the commutator can be given a fine polish with the hand, a muslin cloth, or a piece of drilling. GRADY H. EMERSON.

Asst. Chief Electrician,
Alabama Fuel & Iron Co.,
Birmingham, Ala.

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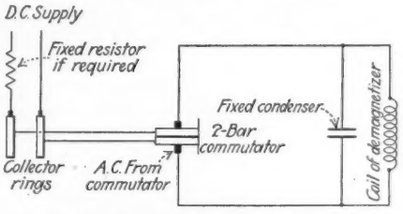
Operating A.C. Demagnetizer on Direct Current.—Will some reader please tell me of a cheap and simple way of changing a 110-volt a.c. demagnetizer so that it can be operated by direct current at the same voltage.

Norristown, Pa. C. D. H.

It will be necessary for C. D. H. to provide means for reversing the direct-current supply. This may be done by mounting two collector rings and a commutator on a shaft, either at the end of the shaft of a small motor or on a shaft mounted in two bearings, which may be belted or coupled directly to a driving motor. The commutator can be made of two parts separated by an insulated break wide enough so that the brushes will not overlap and cause a short-circuit between the parts. If the direct-current supply is fed to the collector rings, an alternating current will be obtained from the commutator.



Method of exciting a demagnetizer from a d. c. power supply.

A two-bar commutator is connected through slip rings to the d.c. power supply. By revolving the commutator at a good rate of speed a supply of alternating - current is obtained for the demagnetizer. Resistors and condensers are used as shown to reduce sparking at the commutator.

It may be necessary to insert a resistor, made up of one or more lamps, or a fixed resistance, in the collector ring to limit the current. A small condenser should also be connected across the demagnetizing coil to cut down and reduce the sparking at the commutator. A telephone condenser will usually be sufficient for the average coil.

It is possible to use an electrolytic interrupter of the Wehnet type, but the writer has not found one of these to be satisfactory if very much current is to be handled.

C. OTTO VON DANNENBERG.
Designing Engineer,
Sanderson & Porter,
Springdale, Pa.

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Answering C. D. H., a demagnetizer, which is nothing more than a coil of wire wound on a suitable supporting frame will magnetize a piece of steel if direct current is passed through the coil. If alternating current is passed through the coil the piece will be demagnetized. This is because the alternating current causes the steel to be magnetized first in one direction and then in another at each alteration, and as the piece is withdrawn from the demagnetizer the magnetism becomes less and less at each alteration, so that when the piece of steel has been entirely removed from the magnetic field it will be demagnetized.

From this C. D. H. will readily see that a demagnetizer cannot be operated as such on direct current; instead of changing the demagnetizer, it will be necessary to obtain alternating current.

This can be done, if the expense is justified, by mounting two collector rings on the shaft close to the commutator of a small d. c. motor. Connect one ring to one commutator bar and the other ring to a bar which is directly opposite, or half-way around the commutator. A suitable brush should be placed on each collector ring. By running the motor from a d. c. supply, alternating current for operating the demagnetizer can be obtained from the collector rings, through the brushes.

Longview, Wash. W. L. HARTMAN.

* * * *

What Kind of Wire Should Be Used?—We are having considerable trouble from grounds and shorts due to the insulation failing on the wires running from our pyrometers to the indicating and recording mechanisms. The pyrometer points are located in the stills and furnaces of a refinery, and the indicating instruments are 200 to 300 ft. away. Consequently, the wires are subjected to considerable heat at one end of the line while the other end is cool. The wires are carried in conduit and we have trouble with condensation in these pipes. Ordinarily rubber-covered, double-braid wire rots out in less than six months. The so-called "flameproof" wire has not proven satisfactory in this application. Can any reader tell me what I can do to correct this trouble?

Tulsa, Okla. L. A. N.

In reply to L. A. N.'s question in a recent issue of INDUSTRIAL ENGINEER, I wish to say that we are using asbestos-insulated wire in conduit, in several pyrometer installations operating at high temperature and have not had any failures in five years. This wire was furnished by the Brown Instrument Company, Philadelphia, Pa.

Chief Electrician, J. S. MURRAY.
Follansbee Brothers Company,
Toronto, Ohio.

* * * *

I would offer the following suggestion to L. A. N. as a remedy for the trouble that he is having. Three years ago we had similar difficulty; our trouble was caused, apparently, from condensation due to warm air entering one end of the conduit and as this warm air strikes the cold section of the pipe, moisture is bound to form on the conductors and on the inside of the conduit, causing the trouble.

To remedy this we plugged both ends of the conduit using plaster of paris. This stopped the passage of air and we had no further trouble.

Chief Electrician, A. C. BARKER.
W. S. Libbey Co.,
Lewiston, Me.

Increasing Thickness of Slot Insulation.—I have a 3-hp. Allis-Chalmers induction motor that is connected two-parallel star. The motor has 48 slots and 48 coils consisting of 25 turns of No. 16 double-cotton-covered wire and is rated at 220 volts, 9 amp., 1,200 r.p.m. This motor gets very hard service, although the load is not excessive, and I would like to decrease the size of wire in it. What change would have to be made in the pitch if No. 17 double-cotton-covered wire were used to

San Diego, Calif. E. A. F.

In reply to E. A. F., I suggest that instead of changing the size of wire from No. 16 d.c.c. to No. 17 d.c.c., he use No. 16 s.c. enameled wire. With this change it is possible to increase the slot insulation 15 mils.

If it is desired to use No. 17 d.c.c. wire, the only noticeable difference will be a slight temperature rise of 3 to 5 deg. C. The coil pitch need not be changed but in case it is, then the number of turns per coil must also be changed.

I have found it good practice to use a total of 40 mils of slot insulation for stators up to 25 hp. operating at 440 volts. This insulation consists of one 25-mil thickness of oiled canvas and another 15-mil thickness of leatheroid or fishpaper.

San Francisco, Cal. P. P. SCRIBANTE.

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Answering E. A. F.'s question about increasing thickness of slot insulation, it will not be necessary to change the winding pitch. If the winding pitch is changed, it will slightly increase or decrease the speed of the motor. Single-cotton-covered and enameled wire will give more room in the slots and will not deteriorate as rapidly as d.c.c. wire under hard service. Decreasing the size of the wire in this case from No. 16 to No. 17 will decrease the horsepower of the motor to a small extent.

The top and bottom layers of the coils in the same slot should be separated with a fibre strip 1/12 or 1/16 in. thick. Between the coil layers at the ends, phase insulation, fishpaper or empire cloth, should be used. In the bottom of the slot a strip of 1/16-in. fibre should be placed and for slot insulation, fishpaper and empire cloth should be used. HARRY J. ACHEE.

Chief City Electrician,
Woodward, Okla.

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Replying to E. A. F. it is not entirely clear to me just what he has in mind by saying the motor is subjected to severe service with no overload, unless severe vibration takes place. However it is not necessary to change the connections or the pitch, if he decides to change the size of the wire.

Not knowing the particular use of the motor it is difficult to understand why the size of the wire should be changed, as my experience with Allis-Chalmers motors leads me to believe that the slot insulation is suitable for the voltage at which the motor is expected to operate. Slot insulation consisting of one piece of 0.015-in. untreated fishpaper, and one piece of 0.010-in. empire cloth is adequate for 220 or 440 volts. It is not always the amount of insulation that is used, but rather how it is used that produces results. I assume that the motor was burned out and perhaps the slot insulation being burned through was the cause of the burnout. There might be a possibility that it was caused by loose wires or dirt in the cell, and when the arc started, it burned through to the iron.

I would consider the motor of much less value if the size of the wire were reduced. My advice would be to rewind the motor according to factory specifications, then give the coils a good soaking in clear baking varnish and when this is thoroughly baked in, apply black baking varnish until it runs clear through the coils in the cells. If you have a megger the winding should be baked until it tests 100 megohms and when it becomes cold the exposed parts of the coils should be coated with black, oilproof varnish, to make a real job with no loose wires. A motor treated this way is almost dirt- and water-proof.

If you have no oven, place a heater inside the motor and close the ends, but do not cover the motor up. Above all things, be sure that the first varnish is thoroughly dry before applying the black varnish, as two distinct coats are much better than two varnishes blended together, as would be the result if the first was not perfectly dry.

Longview, Wash. C. L. HARTMAN.

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In answer to E. A. F., I would suggest that he use No. 16 B. & S. gage s.c.e. wire, which will reduce the amount of wire insulating material and permit the use of thicker slot cells.

The present winding has 50 No. 16 d.c.c. wires per slot and the insulated diameter of No. 16 d.c.c. wire is 0.0598 in., while that of No. 16 s.c.e. wire is 0.0573 in. or a difference of 0.5098—0.0573 = 0.0025 in. per wire. Arranging the 25 wires per coil in a square, five wires wide by five deep the width and depth with No. 16 d.c.c. wire would be 0.299 in. Likewise the insulated width and depth of 25 No. 16 s.c.e. wires would be 0.2865 in. or a saving in slot width of 0.2990—0.2865=0.0125 in., and 2×0.0125=0.025 in. of slot depth using the same size wire with a different covering.

Checking further, the present winding is connected two-parallel-star for 220 volts. Then a series-star connection would change the line voltage to 440 volts with 25 turns per coil. Now, we know that a delta connection requires more turns of a smaller wire than the star connection, and that 25 turns per coil with a series-star connection requires a line voltage of 440, or volts per phase equals 440÷1.73=254.

Using 25 turns and a series-delta connection the line voltage would have to be 254 volts, but owing to the fact that this motor is to operate on 220 volts, the turns per coil will have to be decreased as follows: The series-delta turns per coil equal (220×25)÷254=21.65 or 22, and the size of wire has to be increased in the same proportion as the turns are decreased. No. 16 d.c.c. wire has an area of 2,600 circ. mils while the area of the new size equals (25×2,600)÷22=2,954 circ. mils. The nearest size is No. 15 with 3,250 circ. mils, which would fill up the slot more than the present winding.

However, the new size, with an area of 2,954 circ. mils is only 2,954—2,600 or 354 circ. mils smaller than the No. 16 d.c.c. wire of the original winding. Accordingly 22 turns of No. 16, d.c.c. wire connected series-delta are better to use than 25 turns of No. 17 d.c.c. wire in series-delta, since the latter has an area of 2,030 circ. mils, or a difference in area between No. 16 and No. 17 of 2,600—2,030=570 circ. mils. Judging from these facts, the best winding for this motor for normal rating would be 22 turns of No. 16 s.c.e. wire with the same coil pitch and connected series-delta for 220 volts.

The use of 22 turns per coil means six less turns per slot which, with the room gained by using single-cotton-covered and enameled wire will allow the use of thicker winding cells. The coil pitch does not affect the size of wire except on very close designs where the chord factor changes the number of effective turns, which varies the torque and the current required to produce it.

The above winding will meet the conditions E. A. F. requires and will be found satisfactory under load.

Wilkinsburg, Pa. A. C. ROE.

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Calculation of Rotor Winding for Squirrel-Cage Motor.—I have a 1-hp., 220-volt, Type RI, single-phase, General Electric motor, which I wish to rewind for three-phase operation. I have calculated the winding for the stator, but do not know how to go about figuring the squirrel-cage winding for the rotor. Can any reader give me some help in this matter?

Oakland, Calif. B. B.

In reply to the question by B. B. about changing a single-phase motor to three phase, the rotor need not be considered other than to see that it has approximately 80 per cent of the amount of copper, or its equivalent, used in the stator. It is true that definite rules govern the design of squirrel-cage rotors as to the amount of copper, centrifugal force and so on, but good results have been obtained on the above basis.

As an explanation of the term "equivalent" I refer to the fact that the conductivity of cast copper is about 80 per cent of that of the rolled copper used in the stator, while a cast-brass squirrel cage has about 20 per cent of the conductivity of the rolled copper. The squirrel-cage winding includes both bars and rings.

A fair idea of the relations existing between the three-phase and single-phase designs can be obtained when a squirrel-cage three-phase motor is operating from a single-phase circuit. It can be loaded up to about two-thirds of the three-phase value, if the terminal voltage is increased slightly, or to approximately 60 per cent of the three-phase value with no change. In this event the exciting current will be very high and be likely to approach twice its normal value.

West Allis, Wis. EDWARD JAMES.

Electrical Service

around the works

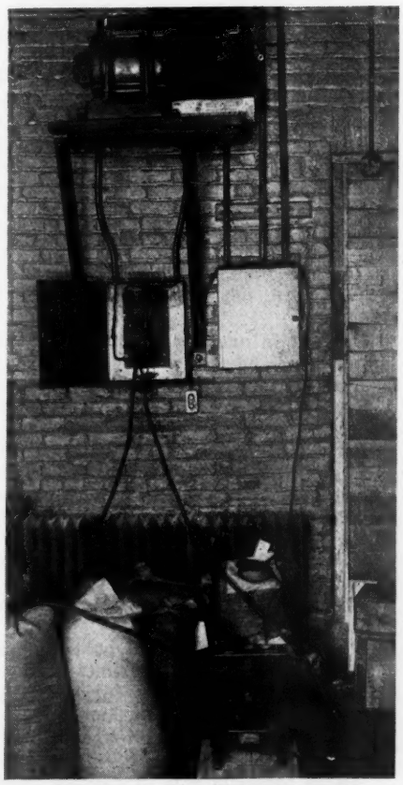
For this section short articles describing ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing, and emergency or special installations.

Handy Portable Starting Device for A.C. Motors

IN COMPLYING with a recent request from a manufacturer for a portable starting device for use with three-phase a.c. motors rated from 1 to 5 hp. and used on machines assembled in his plant, it was necessary to furnish a special magnetic switch formerly used for demonstration purposes.

Mounted on each column throughout this manufacturer's plant was a fused line switch for starting the motors under the old system. In operation, the line test clips on the magnetic starting switch are fastened to the bottom terminals of whichever one of these fused switches is most convenient, and the motor test clips connected to the motor which it is desired to operate, as shown in this illustration.

Because of the size of the driven machines it was necessary to allow about 30 ft. of space around each one while it was being assembled. For that reason a push button with a piece of three-conductor cable long enough so that it could be taken to that part of the machine where it was most needed, saved considerable time. This arrangement enabled the operator to carry the starter to the nearest line switch, clamp on the test clips, push the button and operate the machine easily and conveniently.



The magnetic switch of the starter is connected to the motor line switch and operated by the push button.

Such a scheme could be used to advantage by assemblers or inspectors, in other plants, as it would enable them to keep a close watch of all bearings and rotating parts during a test run and to stop the machine almost instantly in case trouble should develop.

Industrial Control Dept., General Electric Co., Cleveland, Ohio. E. B. SMITH.

Ammeter Indicates Single-Phase Operation of Motors

IN RECENT issues of INDUSTRIAL ENGINEER I have noted several articles regarding the single-phase operation of three-phase motors. Perhaps the following experience may prove to be of interest to some of our readers.

One morning I was called to one of the mill departments by the department superintendent to find out why one of his motors showed such a high reading on the ammeter. As there were other motors running on the same line at the time we naturally thought of an overload at first, but found that all the connected machines were running normally. Then single-phase operation was thought of, but after the motor had been stopped it started again promptly; so the possibility of single-phase operation was dismissed for the time being.

There are three motors, one 50-hp. and two 20-hp. motors, running on the same branch circuit from the main distribution panel, all on one set of fuses, and under those conditions we were unable to understand the behavior of the ammeter. A few minutes later we had occasion to shut down all three of the motors and the cause of the trouble was immediately apparent when we attempted to start again—one fuse was blown.

Two of the motors had an ammeter mounted on their starters. One of these ammeters read high, while the other ammeter, which happened to be in a different phase read low. What happened was that the 50-hp. motor had been started first; then the two 20-hp. motors had been started. During this operation the fuse had blown, but as the 50-hp. motor was running it supplied current for the others and enabled them to be started. As soon as all three motors were shut down it was impossible to start any of them. After the fuse was replaced the motors all started and ran perfectly, the ammeters showing normal readings.

Single-phase operation is difficult to detect with only one ammeter, unless it is arranged with a meter switch so that the current can be read in all phases. Two ammeters will immediately locate the trouble as will also two single phase wattmeters.

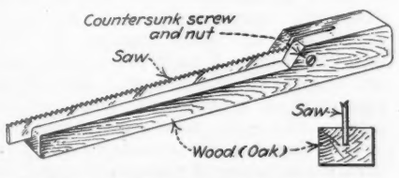
If located in a quiet place single-phase operation can be detected by the peculiar hum of the motor, but in a noisy location no difference can be detected. A speed check is worthless as the change in speed is too small to be of any particular benefit in diagnosing the trouble. Of course, if the motor is left running long enough the coils will become unduly hot in one phase and thus disclose the trouble, but the insulation may be damaged.

Chief Electrician, Donnacona Paper Co., Ltd., Donnacona, Que., Can. LEE F. DANN.

Wooden Stiffener Permits Use of Hacksaw Blade in Close Quarters

IN ELECTRIC wiring and installation work it is often necessary to use a fine-toothed hacksaw blade for cutting off bolt ends, laths inside plastering, cutting cable in confined places, for cutting off pipe conduit placed between floors and in walls and for other uses. Often the work must be done in a corner where it is not practicable to use a hacksaw frame. In such cases it is often possible to greatly increase the facility of cutting with the unsupported saw blade by means of the slotted wooden handle or backing shown in the accompanying drawing. This saw stiffener is used for all such work by one electrician.

The stiffener consists of a piece of oak, slightly longer than the blade, with a slot in one side, into which the saw blade is pressed. The blade is



This wood stiffener makes it easier to use a hacksaw blade in close quarters.

held in the handle by a short bolt with countersunk head and nut. If the slot is made off-center it is possible to get closer to the edge. Also, if the end of the blade is broken off it is possible to get about ½ in. closer into a corner where it is necessary to use only the end of the blade to make the cut. Such a stiffener holds the blade straight and rigid and permits a good, substantial cutting pressure to be applied. A similar stiffener, which would take up less space, could also be made by bending a piece of flat steel to fit on the back of the blade.

Washington, D. C. G. A. LUERS.

Armature Trouble Caused by Opening Field Circuit of Shunt Motor

THE repair foreman at a coal mine was puzzled at the sudden marked increase of burned-out armatures coming to the shop. Investigation failed to locate the trouble for some time, although it was noticed that the motors were coming from the coal-cutting machines. Finally it was ascertained that the operators had discovered that by opening the shunt field circuit temporarily on the motor as soon as the knife was started into the bed of coal, they could speed up the operation to their own gain and the company's expense. Naturally, the armatures did not stand this treatment indefinitely.

The speed of the motor was controlled by a drum controller. Normally, when once the 10-ft. extension arm was started into the bed of coal, the controller was placed on nearly the last notch until the arm had swung nearly through its range. However, as the field leads came outside of the housing which enclosed the motor and were joined by a connector in which the ends of the wires were held by setscrews, the operators had got in the habit of throwing the controller over to full speed and then slipping one of the field leads cut of the connector until the cutter had almost completed its swing.

Boulder, Colo. HAROLD E. BENSON.

How to Determine Power Factor With the Aid of a Watt-Hour Meter

THE subject of system power factor is daily becoming more interesting to the plant engineer. Many who would like to determine and check this value from time to time, are held back only by a lack of the proper instruments.

It has been my experience that almost all plants are equipped with at least one voltmeter and ammeter, but are not always so fortunate as to have in their possession some of the more expensive instruments, such as wattmeters, power factor meters, and the like. However, I have repeatedly used the method of power factor determination outlined below, with very good results. The only instruments required are a voltmeter, an ammeter (with current transformer if necessary), and the watt-hour meter installed at the service switch.

There are in use today, several types of watt-hour meters, but for our purposes they may be divided into two classes: Those in which the rotating element is visible and those in which the rotating element is enclosed so that it is not visible. This latter type is not so convenient to use in figuring wattages, but equally good results may be obtained from the use of either. The first of these methods may be used with any type of meter; the second can be used only when the meter has the rotating element visible.

Connect the ammeter into one phase so that it will measure the entire current flowing through one pole of the service switch. Across this same phase connect the voltmeter. Now determine the number of kilowatt-hours represented by one division of the dial located at the extreme right of the dial plate. If the meter is small, it will in all probability read directly in kilowatt-hours. The larger meters require that the dial reading be multiplied by a certain constant in order to obtain the kilowatt-hour reading. This constant appears on the face of the dial plate.

Having determined the kilowatt-hour equivalent of one scale division, observe the time in minutes required by the pointer to travel over this distance. While making this observation, take readings of the voltmeter and ammeter at regular intervals of one or two minutes.

We now have found a definite number of kilowatt-hours, consumed during a definite interval of time expressed in minutes. Convert this result into kilowatt-hours per hour, by means of the equation:

(1) Kilowatt-hours per hour=(kilowatt-hours measured÷time interval in minutes)×60=kilowatts.

The numerical result obtained from equation (1) is also the average number of kilowatts that were being consumed at any instant during the test.

The average current that was flowing during the test may be found by adding together all the readings of current taken and dividing the result by the number of readings. The average voltage may be found in like manner.

The number of kilovolt-amperes consumed at any instant during the test is then:

(2) Kva.=(average current×1.7×average voltage)÷1,000.

The power factor, expressed as a percentage, may now be found from:

(3) Per cent power factor=(kilowatts÷kilovolt-amperes)×100. In this equation the kilowatts are obtained from equation (1) and the kilovolt-amperes from equation (2).

If the watt-hour meter in question is one having a visible rotating element, the method may be changed somewhat, and the time necessary to determine the power factor considerably shortened.

From the manufacturer's data, or from the meter department of the local central station, obtain the watt-hour constant for the particular type of meter used. This watt-hour constant is simply the number of watt-hours of energy recorded on the meter when the disk makes one complete revolution.

If the information is not easily obtainable, it may be determined experimentally by observing as before, the time interval required by the meter to register a definite number of kilowatt-hours. During this interval take regular readings of the speed of the disk. Determine the average number of revolutions per minute, and find the constant by the equation:

(4) K=[observed number of kilowatt-hours÷(average r.p.m.×time in minutes)]×1,000.

The constant, having once been determined for a certain meter, may be recorded and used for all future calculations.

The watts passing through the meter may be calculated from the standard meter formula:

(5) Watts = $(3{,}600 \times K \times R) \div S$,

In which:

K=watt-hour constant.

R=number of revolutions of the disk.

S=time in seconds required for R revolutions.

The average current and voltage during the time S may be noted as before, and the kva. then calculated from equation (2).

Power factor is found by the following equation:

(6) Per cent power factor=[(watts ÷1,000)÷kilovolt-amperes]×100.

As an aid in following these methods, there is here included an actual example.

A three-phase, 1,200-amp., 550-volt, service switch, has mounted on its panel a Thomson (General Electric) watt-hour meter, type D-3. The meter is rated at 800 amp. when connected through a current transformer of ratio 800 to 5. A voltmeter is connected across one phase and an ammeter with a scale reading from 0 to 5 is cut in on the same phase through a current transformer of ratio 1,200 to 5 (240-1). The watt-hour meter readings must be multiplied by 400 to obtain kilowatt-hours.

By observation it was found that the pointer traversed one division of the right-hand dial in exactly 60 min. The average reading of the ammeter during that time was found to be 2.3 amp. and the average reading of the voltmeter, 601.7 volts. Then by equation (1), Kw-hr. per hr.=(400÷60)×60=400.

Current in one phase=2.3×240=552 amp.

By equation (2)

Kva. = $(552 \times 1.7 \times 601.7) \div 1{,}000 =$ 564.7.

By equation (3)

Per cent power factor= (400÷564.7) ×100=70.8. During the above test, the average r.p.m. of the disk was observed to be 14. Then by equation (4)

K=400÷(14×60)×1,000=476.

And by equation (5)

Watts = $(3{,}600 \times 476 \times 14) \div 60 =$ 399,840.

The value of kva. will be the same as that used in the previous method, since all readings were taken at the same time. Then by equation (6)

Per cent power factor=[(399,840÷ 1,000)÷564.7]×100=70.8.

These methods are, of course, based on the assumption that a balanced load exists in all three phases. This condition practically exists in a plain three-phase motor load.

It will be seen that the result obtained by the first method is quite similar to that obtained by the other. Greater accuracy than a result correct to one decimal place can not be expected.

It is interesting to note that the true watt-hour constant for this meter is 480; this value checks very closely with that obtained by experiment, the percentage of error being less than one per cent.

JAMES P. MARSHALL.
Electrical Engineer,
Cambridge Rubber Co.,
Cambridge, Mass.

Handy Chart for Determining Lighting Requirements

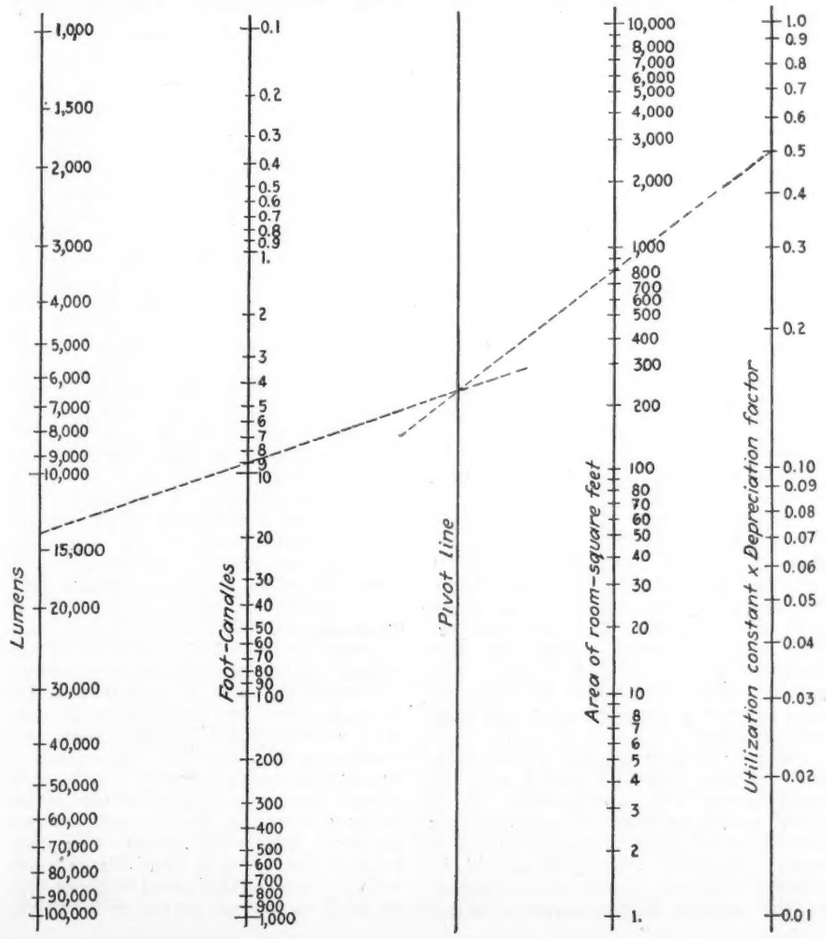
THE accompanying chart may be used for calculating illumination requirements when it is necessary to determine the utilization constant or co-efficient from the character of the room to be lighted. The factors which must be taken into consideration are: color of walls and ceiling, mounting height of lamps above working plane, type of reflector, and distance between lamps. The accumulation of dirt and ageing of the lamps make it necessary to assign values ranging from 75 to 85 per cent for the depreciation factor. Tables covering lighting requirements may be found in the Standard Handbook for Electrical Engineers, or may be obtained from manufacturers of lighting equipment who supply literature concerning their reflectors and fixtures. Several states have codes which specify minimum requirements for intensity of illumination for different locations; consult the Standard Handbook for these.

To use the chart it is necessary to find the utilization constant and depreciation factor, which should be multiplied together. The area of the room is determined and a straight-edge placed on the chart so that it will intersect the Area scale and the Depreciation scale at the points corresponding to these values. Note the point where the straight-edge intersects the Pivot line (center scale). The straight-edge is then shifted so that it intersects the Pivot line at the point previously noted, and the Intensity in Foot-candles scale at the desired value. The intersection of the straight-edge with the Lumen scale, at the extreme left, shows the total lumens required. To find the lumens per outlet, divide the total lumens required by the number of outlets and note the value obtained for determining the size of lamps that should be used. The number of lumens to be obtained from various sizes of lamps will be found from the accompanying table above, which was taken from the Standard Handbook.

CHARLES F. CAMERON.
Rock Springs, Wyo.

This chart will simplify the calculations involved in laying out a lighting system.

Assume that utilization constant times depreciation factor=0.5; area of room=800 sq. ft.; foot-candles desired=9. Place a straight-edge so that it will intersect the area scale and the depreciation scale at the above values. Note the point of intersection with the pivot line. Then place the straight-edge so that it intersects the pivot line at the point noted, and the foot-candle column at 9; read the value of lumens required, 14,400, at the point of intersection on the lumen scale. The size of lamp to be used can be determined from the table.



Illumination Ratings of Mazda C Lamps

Size of Lamp in Watts	Lumens
50	450
75	865
100	1,260
150	2,040
200	3,100
300	4,840
400	6,700
500	8,750
750	13,900
1,000	19,300

Heating Caused by Carrying Each Phase of 3-Phase Circuit in Separate Conduit

CURRENT for the various "sets" in a large moving picture studio was delivered from the three-phase transformers to the switchboard buses at 110 volts. Four 500,000 circ. mil cables for each of the three phases served as the jumpers connecting the transformers and buses; each phase, comprising four cables, was carried in a separate conduit.

When a large number of the sets were being used these conduits became very hot, thus threatening deterioration of the insulation. At no time did the cables themselves carry capacity load, as was shown by checking the load with an ammeter.

Heating of the conduit was assumed to be due to the eddy currents induced in it by the single-phase currents carried by the four jumper cables. That this assumption of the cause was correct is evidenced by the fact that later when extensions were made to the plant and the switchboard buses were revamped, the jumper cables were reconnected so that each conduit carried three-phase current instead of single-phase.

As there were then four cables in each conduit to carry the necessary current and it was desired to use these, besides saving the labor of pulling out the four old ones and pulling in three new cables of the same or slightly greater current-carrying capacity, an extra single-phase cable was left in each of the three conduits.

After reconnecting to the buses, there was still an unbalance of single-phase current in each conduit, but this unbalance was only one-fourth of what it was originally when there were four single-phase cables per conduit. Under the new conditions the conduit hardly heated enough to be noticeable, with the "sets" all pulling full load.

Oakland, Calif. S. H. SAMUELS.

Improper Connections to Motor Cause of Unusual Performance

A SLIP-RING motor rated at 250 hp., three-phase, 60 cycles, 440 volts, 490 r.p.m., which was installed in an aluminum rolling mill, gave indications of overload immediately after its installation. A portable wattmeter connected into the supply circuit at the main switch indicated practically full load when sheets were passing through the rolls. The wattmeter also indicated two-thirds load with no material passing through the rolls. Another peculiar fact was that with the frequency normal, the motor ran at only 1 per cent slip instead of the rated 4 per cent slip.

The electrician who connected the motor was not on hand at the time these peculiar symptoms were noted and as the wiring was concealed in a large metal conduit imbedded in the floor, a superficial inspection failed to indicate the nature of the trouble.

The solution was finally found by means of our old friend, the voltmeter. The nameplate of the motor gave the rated voltage between the collector rings as 380 volts. The voltmeter, when connected across two rings, showed 440 volts. This reading checked with the voltage given at the control panel. Apparently the electrician had connected the rotor to the supply lines, and the stator to the resistance.

This assumption was found to be true when the wiring from the control panel was uncovered and the connections traced. With the proper reconnection of the motor wiring, the motor carried its load without heating, the speed returned to normal and the wattmeter indicated the true load on the motor.

DEAN W. TAYLOR.
Industrial Power Engineer,
Metropolitan Edison Co.,
Reading, Pa.

Specially-Connected Series Motor Substituted for Shunt Motor

RESOURCEFULNESS is a quality that is essential to every plant maintenance man. One of the best ways of developing this much-desired quality is to learn the method by which others have coped with similar difficulties. The following is a good example of the resourcefulness of one plant electrician.

A skelp mill in the Chicago steel district has 11 roll stands. The first seven stands or sets of rolls are driven by a Kraemer adjustable-speed set; the eighth stand, which consists of two edging or vertical rolls, is driven by a 160-hp., 250/500-r.p.m., shunt-wound motor; and the last three stands are driven from a second Kraemer adjustable-speed set. Skelp or strip steel is in all 11 stands at once; hence the necessity of accurate speed adjustment of the different sets of rolls can be seen.

While a 160-hp. motor was used on the eighth or edging stand drive, it was considerably over-motored, only about 80 hp. being required. The speed of the drive was determined by the weight of skelp being rolled, but generally the motor speed was about 500 r.p.m.

One Saturday afternoon the V-rings of the commutator loosened to the point where the commutator exploded; that is, the segments went all over the mill. This accident shut down the entire skelp mill and at once entailed a considerable production loss.

Investigation showed that what could be found of the commutator was damaged beyond repair; also that parts of the commutator had hit the field coils, tearing off portions of the winding. The bands on the armature had been loosened by the accident and the armature winding came out of the slots sufficiently to be jammed in the air gap. The mechanical shock resulting from the accident also broke one of the bearing pedestals; so the motor was more or less of a total wreck. To make matters worse, although there was a spare armature, it could not be used without a good motor frame and the frame on the wrecked motor was damaged more than could be repaired in the 40 hours remaining before Monday morning. At this point the resourcefulness of the plant electrician came into play.

He conceived the idea of using a series-wound motor in place of a shunt-wound, adjustable-speed motor. There were plenty of series-wound, totally-enclosed, mill-type motors available; so the plant electrician decided to install one in place of the wrecked motor. He thought that by connecting the series field of the mill-type motor across the line through resistance, he would be able to get the desired speed.

The requirements of the drive were, as previously stated, approximately 80 hp., at 500 r.p.m. An 80 frame, Type MC Westinghouse mill-type motor has a mill (1-hr.) rating of 80 hp. When used as a series motor it delivers a speed of 500 r.p.m. at this load. This data can be taken from the performance curves of the motor. Since the motor was rated at 230 volts, the line current at this load will be 280 amp. Therefore, to run the motor at 500 r.p.m., with an 80-hp. load, requires a current of 280 amp. in the series field.

In determining the amount of resistance to connect in series with the field so as to place the field directly across the line, the resistance of the field was neglected. Resistance equals voltage divided by current; hence, $230 \div 280 = 0.8220$. Therefore, the amount of resistance required for connection in series with the field would be 0.8220 ohms and the resistance should have a carrying capacity of 280 amp.

The series field was connected in series with a sufficient number of resistance frames, having heavy-duty, cast-iron grids to give this resistance. An ammeter was connected in series with the resistance and the combination was connected across the line through a switch and fuses. The amount of resistance was adjusted until a current of approximately 280 amp. was obtained.

Power was then applied to the armature of the mill-type motor and the combination ran successfully as a shunt-wound machine. After running a few pieces of skelp through the rolls it was found that the speed should be slightly different than at first supposed; so the amount of resistance in series with the series field was changed until the desired speed was obtained.

This combination was ready to start with the Monday morning shift. It was closely watched, however. The first trouble encountered was that the series fields began to overheat. They were designed for an intermittent rating and were being used continuously. So an air hose was put in one of the hand holes to aid in circulating cooling air.

Although the motor overheated considerably, it ran successfully throughout the week. At the end of the week, it was decided to put in the next larger frame of motor in order to obtain a performance that could be depended upon until a new motor was obtained.

A 230-volt series-wound, 90 frame, Type MC, totally-enclosed, Westinghouse motor delivers 100 hp. at 500 r.p.m. on the mill or 1-hr. rating. At 230 volts a current of 350 amp. is required for this load. With the series field shunted across the line, a resistance of $230 \div 350 = 0.656$ ohms is required to limit the field current to the 350-amp. value.

The 90 MC motor was installed with a resistance of 0.656 ohms, and having a continuous carrying capacity of 350 amp. The larger motor required an air hose to help keep the fields cool; however, this motor ran satisfactorily for two and one-half months, until the regular shunt motor was installed.

Indiana Harbor, Ind. A. J. W.

Mounting Transformers on Skid Facilitates Testing Out New Machines

THE problem of providing current of the various voltages and cycles necessary in testing out new equipment, which is fitted with a special motor to suit the customer, is well handled by one special machine manufacturer. The voltages of these motors are usually 110, 220 or 440. Power is purchased at 220 volts, 60 cycle. Power outlets are located at convenient points throughout the plant. Also, a motor-generator set will provide direct current which is put through a special test board to give various voltages desired.

To get 110- or 440-volt, 60-cycle, alternating current, use is made of two, pole-type, distribution transformers, which are placed on a skid or platform handled by an elevating-platform, hand-lift truck, so that they can easily be taken to any part of the plant. One transformer is connected up to step the 220-volt supply down to 110 volts. The other transformer is connected to deliver 440 volts, on the secondary side.

If a motor is rated at any one of these voltages, it is tested at full load. In case the motor is of an odd voltage or odd number of cycles, as for example 550 volts, 25 cycle, it is tested at 440 volts, 60 cycle, but the machine is operated without load. If the motor will satisfactorily operate the machine empty, the manufacturer is willing to accept the responsibility of the design being correct, so that it will operate properly under full load. The main point is to be sure that the machine will operate smoothly and will not bind or stick at various points in its travel.

Mechanical maintenance of

Power Drives

This department will furnish mechanical details of installation, operation and maintenance of equipment in the path of power service from the first mechanical driving element through the auxiliary transmitting equipment to all driven machines.

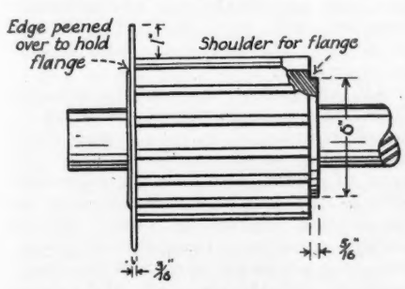
Repairing Worn Flange on Pinion of Chain Drive

IN a plant built in 1902 the two a.c. generators are supplied from two 220-volt, 200-amp. exciters with Link-Belt silent chain drives, 6 in. wide and 1 in. pitch. Twice in their life of usefulness, the bearings of these exciters have been rebabbitted. The last time the bearings were out, the armature shafts were taken out and the commutators lathe-turned and undercut. However, the principal reason for shopping the equipment was to repair the sprockets. The chains used depend upon flanges at the ends of the sprockets to keep them from running off. These flanges were so badly worn and low that the chains would occasionally jump up on them with the fluctuations of the load. There was not enough slack in the chain to take out a pair of links and the adjustment take-up had gone the limit of the rails.

The method of repair is shown by the accompanying drawing. New flanges, which were made higher than the old ones—actually double the height above the teeth—were put on. These flanges were cut from sheet steel, bored to fit a turned shoulder at each end of the sprocket, and were peened fast; a slight countersink in the flange, and a high shoulder enabled this to be done in a very secure manner. The outside diameter of the flanges was turned in place and the corners were well rounded over. One machine was repaired first and, as it proved to be very satisfactory, a duplicate job was done on the second.

This is a good example of the long service that it is possible to obtain from a chain drive. The service to which these chains are subjected imposes an intermittent load on them, yet no one connected with the plant recalls any chain breakage. One of the chains is still in good running condition, the other is to be renewed, and both sprockets are as serviceable as new, although the tips of the teeth are rounded instead of clean cut as they were at first.

DONALD A. HAMPSON.
Plant Superintendent,
Morgan & Wilcox Mfg. Co.,
Middletown, N. Y.



The old flanges, which had worn too low to retain the silent chains on the sprockets, were replaced by these disks.

Where and Why Lineshafts Break in Service

TRANSMISSION shafting carrying driving or driven pulleys or rope sheaves as a general rule break just inside the hub of the pulley. The reason for this is not hard to understand. A shaft that carries pulleys and transmits power is subjected to two main forces tending to disrupt it. The principal one of these forces is that of twisting, caused by the turning of the shaft. The result of this force is called the twisting moment; and if we assume a length of shaft between any two hangers and with no pulleys thereon, this twisting moment will be the only force to which the shaft is subjected, neglecting the weight of the shaft. The load on the shaft will be that due to the amount of horsepower that is being transmitted.

If now we consider a length of the shaft between two hangers, but which has a pulley located on it at some place, we have a different condition. Forgetting for the moment that the shaft revolves, we can consider the shaft as a beam loaded at some point with a concentrated load, the pulley in this case being the load. This condition tends to deflect the shaft just as in the case of a beam, or in other words to create a bending moment. If the pulley or sheave is midway between the bearings this bending moment will be a maximum. As the location of the pulley moves nearer either hanger the bending moment decreases.

A shaft in motion carrying pulleys is, therefore, subjected to a combined twisting and bending moment which is greatest in the hub of the pulley, and it is for this reason that shafts break at this place. If the belt is put on so tightly that the shaft is deflected, as is often the case, there will be an additional bending moment caused by this condition.

The fact that shafts tend to break in the pulley hubs, rather than elsewhere, is an advantage in one way since they usually give warning before they disrupt completely, and thus avoid wrecking the transmission equipment or the machinery that is beneath. The breaks are not as a rule sudden and complete, but start at the outer surface and progress gradually across the shaft. In the meantime there will be indications of trouble. The belt may tend to run to one side of the pulley; the adjacent bearing may heat; the shaft just outside the hub and sometimes the hub itself may heat; the pulley may wobble; or there may be a grating sound heard at times. Any one of these indications should be investigated as soon as possible after being noticed, as it may mean a broken shaft.

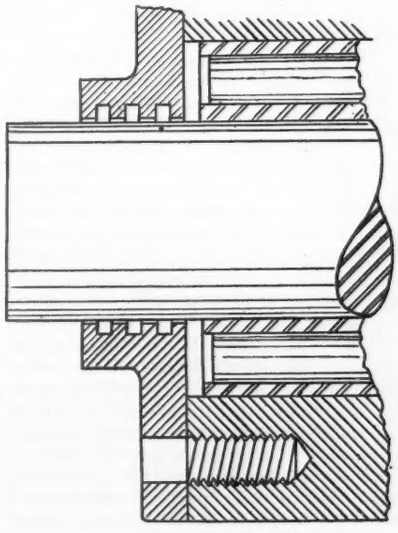
The remedy for such trouble is to use shafting of ample size for the load and locate the pulleys as closely to the hangers as possible; or better still, place a hanger on each side of the pulley.

JOHN A. COLLINS, JR.
Lawrence, Mass.

Using Grooved Caps to Prevent Oil Seepage From Roller Bearings

THE customary method of retaining oil in a roller bearing is by using end caps recessed for a felt ring. For example, a bearing on a 2-in. shaft will have the caps recessed so that stock felt washers of $\frac{1}{8}$ in. or $\frac{3}{8}$ in. square cross-section can be crowded into the space and press upon the shaft. However, unless the washers are changed occasionally they become glazed from the rubbing of the shaft.

There is another method that has much to commend it, but is not so com-



Oil which seeps out from the bearing along the shaft is thrown off into these three grooves.

monly used, which does not require felt or other self-adjusting mediums for making the closure. How this is accomplished is shown in the accompanying illustration. The bearing cap is bored to a diameter 0.01 in. larger than the shaft. This leaves a gap ample for all necessary clearance, but not so great as to cause undue seepage of oil. If the cap for the 2-in. shaft bearing is made long enough to permit cutting three grooves ⅛ in. wide and ⅛ in. deep, as shown, there will be very little loss of oil, as the oil is thrown off as it creeps outward along the shaft, and is caught in the grooves. The oil will be returned to the bearing if a drain hole has been made on the inside. This method of retaining the oil does not lose any of its effectiveness with age, and may be used on any other bearing having an end cap.

Factors in Selection of Speed Reducers of Proper Capacity

ONE of the interesting developments in power transmission during the last few years has been the rapid growth in the use of unit speed reducers and their applications to varied forms of machinery and industrial equipment. Much has been written on this subject in regard to design, features, principles of operation, and construction of the different types and the advantages of unit speed reducers as compared with other forms of speed reduction equipment such as belts and pulleys, chains and rope drives, open gearing, and so on.

To the engineer or plant executive, it is of even greater importance to have fundamental information covering the application of these machines to various forms of equipment, with the basic formulas and a knowledge of their application to practical problems which will enable him to estimate requirements on specific jobs and aid in selecting units of proper type, capacity, and reduction ratios.

The information on spur-gear, speed-reducer calculations presented is applicable to any of the standard types of spur gear reducers now on the market, including the plain, spur, planetary and non-planetary types, and also the herringbone type. Worm-gear reducer problems require a little different handling. It is hoped that the information will prove interesting and helpful to those who are concerned with transmission and speed-reduction problems.

The principal point to be remembered in dealing with speed-reduction problems is that theoretically the same horsepower is delivered by the reducing unit as is delivered to it by the prime mover. The speed, however, decreases through the reducer, depending upon the reduction ratio used, and the torque or twisting moment correspondingly increases. It is necessary to have a clear understanding of this subject in order to make a proper selection of speed reducers to meet a given set of conditions. The various elements which are factors in all speed-reduction problems are as follows:

P=Load in pounds.

R=Radius in inches of drum or pulley.

$2\pi R$=Circumference of drum or pulley (inches).

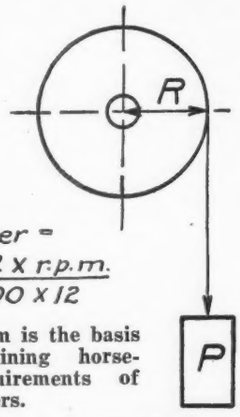
N=Revolutions per minute (r.p.m.).

T=Torque or twisting moment in inch-pounds.

W=Work done.

$Hp.$=Horsepower. (33,000 ft.-lb. per min.)

Torque or twisting moment is that force which tends to produce rotation in a shaft or pulleys and is equal to the product of the force exerted times the length of the lever arm. T is expressed in a formula (see accompanying illustration): $T=P\times R$.



$$\text{Horsepower} = \frac{P \times 2\pi R \times \text{r.p.m.}}{33{,}000 \times 12}$$

This diagram is the basis for determining horsepower requirements of speed-reducers.

Work done is equal to the product of the force acting on an object times the distance through which it moves. Thus, where D = distance traveled, then, $W=FD$.

The distance through which the force acts in one revolution is equal to the circumference of the circle, which is $2\pi R$. Therefore, work done in one revolution is: $W=P\times 2\pi R$ in.-lb.

If the drum or pulley makes more than one revolution the total work done will be: $W=P\times 2\pi R\times N$ in.-lb.

Since 1 hp. is equivalent to 33,000 ft.-lb. per min., the horsepower required to revolve the pulley N times per minute against the weight P will be: $Hp.=(P\times 2\pi R\times N)\div(33{,}000\times 12)$.

Other useful formulas are derived from these equations as follows:

$Hp.=(T\times N)\div 63{,}025$.

$T=(63{,}025\times hp.)\div N$.

$T=P\times R$; $P=T\div R$; $R=T\div P$.

By using one or more of the above formulas it is possible to solve practically any speed reduction problem which may be presented; some of the methods used are indicated in the simple problems which follow. Let it be borne in mind, however, that in actual practice, the efficiency of both the reducer and the driven machine must be considered, when selecting reducers of the proper size.

(1) If we have a drum with a radius of 12 in. and a load of 2,000 lb. find the torque necessary to move it.

$T=P\times R=12\times 2{,}000=24{,}000$ in.-lb.

(2) If the drum is to be driven at 1 r.p.m. how much work will be done during one revolution?

$W=2\pi\times T\times N=6.28\times 24{,}000\times 1=150{,}720$ in.-lb.

(3) How many horsepower will be required to drive this drum at 20 r.p.m.?

$Hp.=(2\pi R\times P\times N)\div(33{,}000\times 12)=(6.28\times 12\times 2{,}000\times 20)\div(33{,}000\times 12)=7.61$ hp.

(4) If we know that the torque on the drum shaft is 24,000 in.-lb. what hp. would be required to drive it at 20 r.p.m.?

$Hp.=(T\times N)\div 63{,}025=(24{,}000\times 20)\div 63{,}025=7.61$ hp.

(5) If 7.61 hp. is required to drive this drum at 20 r.p.m. what is the torque in inch-pounds on the center of the drum shaft?

$T=63{,}025\times hp.\div N=(63{,}025\times 7.61)\div 20=24{,}000$ in.-lb. torque.

(6) If the torque or twisting moment at standing load is 24,000 in.-lb. and radius of drum is 12 in., what is the load on the drum in pounds?

$P=(T\div R)=(24{,}000\div 12)=2{,}000$ lb.

(7) If the torque on this drum shaft is 24,000 in.-lb. and the load on the drum is 2,000 lb. what is the radius of the drum?

$R=T\div P=24{,}000\div 2{,}000=12$ in. radius or 24 in. diameter.

We cannot over-estimate the importance of carefully calculating actual torques on the driven unit, as a basis of determining horsepower required to move the load. This is particularly true in cases where high reduction ratios are used and the final speed is only a fraction of a revolution per minute.

The capacity of the driving unit must always be great enough to compensate for frictional and other losses in the reducing unit and driven unit, and also to start the load on the driven unit, even though the power required while running is much less.

Assuming the conditions for a practical problem, the foregoing formulas may be used as follows to carry the calculation through to the selection of the proper size and type of spur-gear speed reducer for a particular installation. The problem concerns the selection of a motor and reducer for a conveyor with a mechanical efficiency of 80 per cent. The headshaft of this conveyor is to be driven by a spur-gear speed reducer at 25 r.p.m. The total load to be moved is 4,000 lb. The pitch radius of the sprocket driving the conveyor belt is 18 in.; and 800-r.p.m. motor is to be used. The formula for this is:

$Hp.=(2\pi R\times P\times N)\div(33{,}000\times 12)=6.28\times 18\times 4{,}000\times 25)\div(33{,}000\times 12)=28.54$ hp.

As the efficiency of the conveyor is 80 per cent, the actual horsepower required will be: $28.54\div 0.80=35.67$ hp.

The efficiency of the reducer is 95 per cent, and so the size of the motor required will be: 35.67 hp.$\div 0.95=37.55$ hp. The reduction ratio is 800 to 25 or 35 to 1.

All that is now necessary is to select from the manufacturer's catalog a speed reducer of a rating and ratio conforming to the above results. In case of doubt, or when an especially difficult problem in connection with an installation operating under severe service conditions is under consideration, it is advisable to consult the Engineering Department of the speed reducer manufacturer.

Chief Engineer, HARRY C. PETERSON.
Foote Bros. Gear & Machine Co.,
Chicago, Illinois.

In the Repair Shop

This section is devoted to repair work on electrical and mechanical equipment. Special attention is given to shop or bench tools and short cuts or improved methods of handling work of this character. Contribution are always welcome.

Rewinding Two-Phase Motors for Three-Phase Operation

FREQUENTLY occasions arise when it is desirable to change a two-phase squirrel-cage motor for three-phase operation. In this case the first thing to do is check the three-phase line voltage with the two-phase winding connected series-star or series-delta. With this information it is a simple matter to determine a suitable three-phase connection with the required number of turns per coil and correct size of wire.

For a specific case we will consider a two-phase, 5-hp., 60-cycle, 220-volt, 1,200-r.p.m. squirrel-cage induction motor which it was desired to change to three phase, with the same horsepower rating, frequency, voltage and speed. The two-phase winding data were, 48 slots and 48 coils wound 23 turns of No. 15 s.c.e. wire, 12 groups of four coils per group, coil pitch 1-and-8, six poles, connected two-circuit.

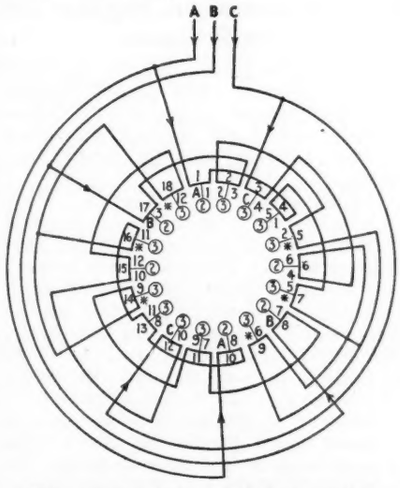
The three-phase, series-star line voltage equals $C \times V_2 \times 1.212$ and the three-phase, series-delta line voltage equals $C \times V_2 \times 0.707$, where C equals number of circuits in the two-phase winding and V_2 equals the two-phase line voltage. Therefore, the series-star line voltage equals $2 \times 220 \times 1.212 = 537$ volts and the series-delta line voltage equals $2 \times 220 \times 0.707 = 313$ volts.

From the above results it is obvious that reconnection is not possible; therefore, the next step is to figure a new winding. First, try the series-star winding for a line voltage of 440, as this winding can be connected two-parallel star for 220 volts, and figure the turns for 440 volts, instead of 220 volts. This will keep the turns per coil high and the size of wire small, which is better for winding, as mush-type coils wound with small wire are easy to shape while winding on the stator.

When computing the new turns per coil use the formula, $(T_2 \times V_0) \div V_2$, where T_2 equals the old number of turns in the two-phase coil, V_0 the required three-phase line voltage and V_2 the line voltage derived from the voltage formulas given above. In this case the number of new three-phase turns for series-star and 440 volts equals $(23 \times 440) \div 537 = 19$ turns plus and the number of turns for 440 volts, three-phase, series-delta equals $(23 \times 440) \div 313 = 32.4$ or 33 turns plus per coil.

Judging from the number of turns computed, the star-connected winding will give the best results, as the turns per coil are lower and the size of wire larger, but still small enough for a mush-coil that will shape readily. The reason for selecting this winding is that it provides a better space factor, that is, more copper and less insulation, than 33 turns of smaller wire would require.

The new size of wire in circ. mils is equal to $(T_2 \times A_2) \div T_3$, where T_2 equals the old number of two-phase turns per coil, A_2 the area in circ. mils of the old two-phase conductor, and T_3 the new, three-phase turns per coil. In this case the new size of wire equals $(23 \times 3{,}257) \div 19 = 3{,}942$ circ. mils. The nearest size to this is No. 14 with 4,107 circ. mils. Checking for slot room, $23 \times 3{,}257 = 74{,}911$ circ. mils, and $19 \times 4{,}107 = 78{,}033$ circ. mils. Then, $78{,}033 - 74{,}911 = 3{,}122$ circ. mils, which is less than one No. 15 wire per coil or two No. 15 wires per slot. Thus 19 turns of one No. 14 s.c.e. wire will be the more satisfactory to use.



This shows the new three-phase, 220-volt, six-pole, winding, connected two-parallel star.

This motor was originally wound for two-phase operation. In the new winding there are 18 coil groups, numbered from 1 to 18; the number of coils in each group is indicated by the figures in the circles. The coil leads are also designated by figures to show the order of connection.

The three-phase, 220-volt, six-pole, 1,200-r.p.m., 5-hp., winding data are, 48 coils, each wound with 19 turns of one No. 14 s.c.e. wire, pitch 1-and-8, connected two-parallel star, 18 groups, or 12 groups of three and six groups of two coils per group, connected as shown in the accompanying diagram.

Wilkinsburg, Pa. A. C. ROE.

Correcting Usual Troubles With Insulating Varnishes

MOST of the difficulties encountered with insulating varnishes are due to failure to understand troubles which come as the result of not knowing what will happen under various conditions in the use of such varnishes. Some of the more common troubles are discussed in a bulletin on insulating varnishes and compounds recently issued by the Sherwin-Williams Co., Cleveland, Ohio. The more important sections are as follows:

Curdling or separation of different components of the varnish may be due to a number of causes among which are adding thinner while the varnish or thinner is too cold, adding the thinner too rapidly and not stirring it in thoroughly, allowing the cover of the dipping tanks to remain open, thus causing the varnish to partially oxidize, or using a thinner which is deficient in solvent properties. It is most important that a good quality benzine be used as many of the benzines now on the market are mixtures of light and heavy oils and are not good solvents.

Black spirit varnishes, when shipped in tin cans, sometimes thicken up after the can has been opened. This is due to a chemical reaction which takes place between the dye in the varnish and the iron of the can, as most commercial tinplate is imperfectly coated with tin.

When varnish is applied by dipping, metal tanks should not be used. Wooden tanks or tubes are best.

Low dielectic strength is generally due to the varnish not being thoroughly hardened. The remedy for this is obvious.

Corrosion of the copper wires is due in every case to the varnish not being thoroughly oxidized. Oil-type varnishes contain vegetable drying oils and these oils are compounds of glycerin and various fatty acids. In the combined state these oils are neutral, and after they have been combined with oxygen in the process of drying, they are changed into entirely different substances which have no acid character whatever. However, if a long-oil varnish is applied to a coil and then not completely oxidized, the unoxidized oil will, after a time, under the action of the heat which is present in all electrical apparatus, decompose into glycerin and free fatty acids and it is these free fatty acids which cause corrosion.

The remedy lies in the method of using the varnish. Reduce the thick-

ness of coating or increase the baking time until the varnish is thoroughly dried. Make sure that the coils are not draining in such manner that the varnish collects in pockets. If these measures fail to correct the trouble, the only alternative is to use a shorter oil, quicker baking varnish which can be thoroughly dried in the length of time permissible.

Softening of enameled wire is due entirely to the manner in which the varnish is used. Benzine is the mildest solvent available for making varnishes. Turpentine and coal-tar distillates are much stronger solvents and if used in an insulating varnish will attack the enamel on enameled wire. Under certain conditions, a benzine-solvent varnish may affect the enamel. If the coils after dipping are placed immediately in the oven and the baking started at a high temperature, the benzine will be boiled.

As is generally known, the solvent properties of any solvent are greatly increased by heating. Also, the heat tends to soften the enamel and make it more readily affected by the benzine and while at the lower temperature benzine has no effect, at the higher temperature the combined softening and solvent effect may injure the enamel. There is also a possibility that the high heat may rapidly oxidize the varnish on the surface and form a film which will prevent the escape of all the solvent underneath. The enamel would then be subjected to the action of this solvent throughout the entire baking period.

The remedy for this trouble is to allow plenty of time for draining and to start the baking at a low temperature and continue at this temperature until all the benzine has evaporated. The temperature can then be adjusted to the regular baking temperature. A baking temperature of not over 85 deg. C. is recommended for the first two hours of baking.

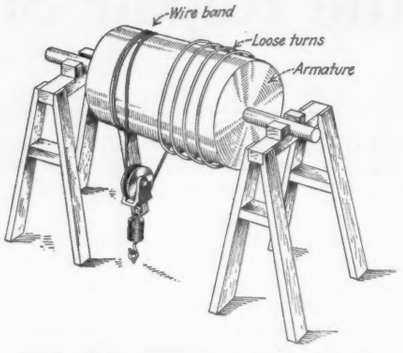
Method of Banding Armature When Power Is Not Available

IN AN article on page 453 of the September, 1925, issue of INDUSTRIAL ENGINEER, Maurice M. Clement described how an armature was banded which was too large for handling in a lathe. This brings to mind a method that can be used where neither a lathe nor any other machine suitable for this type of work is available.

As shown in the illustration, the armature to be banded is placed between two ordinary saw-horses or other suitable supports. One end of the banding wire is fastened on a part of the core between any two band spaces. Then sufficient wire for banding is wound loosely on the armature, allowing a few extra turns. The end of the wire is brought through a single block pulley suspended underneath the armature, as shown, and back around the armature, starting the first band in the usual manner.

A spring attached to the floor, as shown in the illustration, a weight hung directly on the block, or a combination of lever and weight may be used to give the desired tension on the wire.

By this method of banding, the power required to turn the armature



With the armature mounted on suitable supports, enough wire for banding is wound on loosely. After starting the band, tension is put on the wire by means of a spring or weight.

is only that needed to overcome friction. The weight or spring always keeps the wire under tension and the armature can be stopped and left in any position without blocking it to keep it from turning. Further, no adjustment of the wire tension is required, as it will always be constant.

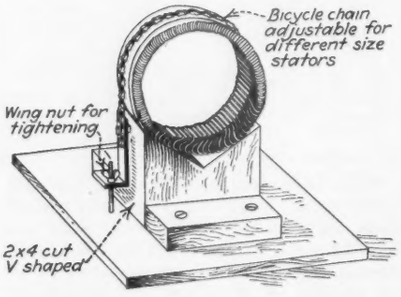
Philadelphia, Pa. HOWARD DAVIES.

Easily Constructed Support for Small Stators

IT IS oftentimes difficult to hold small stators while an old winding is being replaced or repaired. Consequently, the stator support illustrated in the diagram will be found very useful.

To make this, a 2-in. by 4-in. block of wood is cut V-shaped and fastened by wood screws to a suitable flat surface or bench. For additional support two strips of wood are fastened down alongside the front of the block on the 4-in. side. An old piece of chain, preferably bicycle chain because of its flexibility, is used to hold the stator which rests in the V-shaped groove.

One end of this chain is fastened to a wood screw located on the narrow side of the 2-in. x 4-in. wood block. By hooking the chain over this wood screw, the head of which is filed off on opposite sides in order to slip through the



This support for small stators can be readily adjusted to fit different sizes of stator frames.

links, quick adjustability can be obtained for any length of chain required. An L-shaped iron strip is securely fastened by means of a small bolt to the other end of the chain. A wing-nut and bolt which passes through the lower end of the L-shaped piece serves to tighten the chain, so as to hold the stator firmly while working on it.

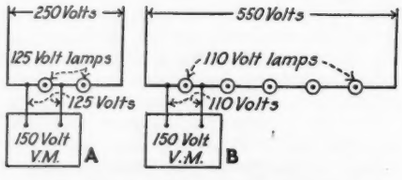
Different sizes of stators may be handled by first adjusting the chain to approximately the desired length, by slipping it over the wood screw at the proper point, and then tightening the wing nut.

Kincaid Electric Shop, J. P. KINCAID.
Durant, Okla.

How to Check Voltages Higher Than Capacity of Voltmeter

OCCASIONS arise in testing or repair work where it is necessary to measure voltages that are higher than the capacity of any available voltmeter. A simple method of overcoming this difficulty is to place lamps of known voltage in series across the line to be tested.

In a series circuit the voltage drop across each lamp is the same, providing the lamps are of equal resistance and size. A check by placing the voltmeter terminals across each lamp will readily



Voltages higher than the capacity of the voltmeter may be measured by placing a sufficient number of lamps in series across the line and taking the voltage drop across the terminals of one lamp.

The voltage of the circuit will then be equal to the voltage drop across one lamp times the number of lamps in series.

prove this. The readings should be the same and, of course, the number of lamps in series times the voltmeter reading will equal the voltage across the line.

The voltage and number of lamps to be used will depend on the voltage of the supply. In the diagram, *A* shows how the voltage of a 250-volt circuit may be checked by putting two 125-volt lamps in series across it and reading the voltage drop across the terminals of one of the lamps. A 550-volt circuit may be checked in the same way by using five 110-volt lamps in series, as shown in *B*.

This method will be found very satisfactory where great accuracy is not required, and will make it unnecessary to buy additional voltmeters which would be used only for occasional testing. If several lamps are connected in series, tested to make sure that they are well matched and retained for testing purposes, the trouble of connecting them up each time will be eliminated.

Philadelphia, Pa. HOWARD DAVIES.

Convenient Testing Equipment for Fuses and Lamps

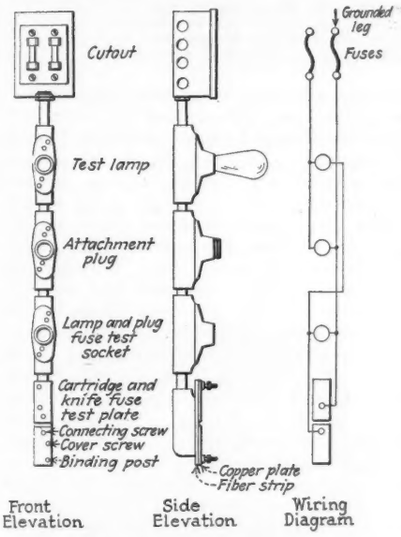
IN MANY small industrial plants the only available equipment in the maintenance shop for testing fuses and lamps to see if they are burned out, or for detecting shorts or grounds on equipment, is a convenient cutout and the electrician's old stand-by, the weatherproof socket spliced to a piece of lamp cord. Even in plants that have excellent facilities for testing large motors, testing in the shop of fuses or lamps from stock is done with the above-mentioned makeshift connections.

Both time and money are wasted when valuable equipment and operators stand idle, because general maintenance men, lamp cleaners or operators have replaced blown fuses or burned-out lamps with bad fuses or lamps from the department stock. Then the electrician is sent for to repair supposedly defective equipment, while men and machines stand idle. Such delays can be prevented if testing facilities are available for those whose duty it is, to replace blown fuses or broken lamps.

For this reason in one plant I made up some inexpensive testing outfits of conduit fittings, like the one illustrated in the drawing. It was so convenient to use that it prevented untested lamps or fuses from being used for replacement. The lamp and plug fuse testing socket was made by removing the shell of a receptacle and hammering the threads flat, using a piece of ½-in. pipe for an anvil. The lamp or fuse could then be pushed into the socket without being screwed in. This eliminated labor on the part of the person using it and encouraged its use. By substituting a brass disk about ¾ in. in diameter for the spring contact in the base of the receptacle, and raising this disk by placing fibre washers under it so as to make the socket shallow, single-contact bayonet-base lamps used in automobiles and candlelabra-base lamps used as indicating lamps could also be tested.

The test plate for cartridge and knife fuses is made by securing two copper or brass plates to a piece of ¼-in. fibre about 6 in. long and separating the two plates about ⅛ in. Care must be taken to countersink the heads of the cover screws so that they will not come in contact with the plates and cause a short-circuit across the device. Fuses ranging in size from instrument type to those of 200-amp. rating can be tested by placing them across the plate. Larger, or high-voltage, fuses can be tested by placing a screwdriver or any handy piece of metal on one of the plates and touching it to the fuse end. Double-contact, bayonet-base lamps can also be tested on the plate. By placing binding posts on the ends of the test plates, leads may be taken off for testing for shorts or grounds when repairing small apparatus at the bench. Ordinary test leads that are permanently fastened at one end have a very short life, as every electrician knows, and usually when one is in a hurry to use them they are broken. By the use of these binding posts any scrap wire around the shop can be quickly attached to make an improvised pair of test leads whenever occasion demands or for an emergency.

By using a 50-or 60-watt lamp as a test lamp, all types of lamps can be tested from a 2 c.p. auto-lamp to a 200-watt lamp. There will be no danger of burning out the small, low-voltage lamps when they are tested on 110 volts in series with the test lamp. The larger lamps, of course, will burn only very dimly when in the test socket. In wiring be sure to bring the hot leg to the test lamp and the grounded leg to the testing devices, to prevent accidental shorts from grounds.



Here is a testing outfit that is made of standard conduit fittings and will facilitate the testing of lamps, fuses and other equipment.

The material required and the cost of this testing device is as follows:

Material	Cost
1 3-in. by ½-in. by 5-in. cutout box	$0.35
1 2-wire, 30-amp. cartridge fuse cutout	.40
2 15-amp. cartridge fuses	.30
3 Type C conduit fittings, ½ in.	1.11
1 Type E conduit fitting ½ in.	.27
3 Conduit fitting receptacles	.81
4 ½-in. by 2-in. nipples	.20
1 ½-in. locknut	.01
1 ½-in. bushing	.02
8 ft. No. 14 R. C. wire	.06
For Test Plate	
1 piece of fibre ¼ in. by 1¼ in. by 6 in.	.06
2 pieces of copper ⅛ in. by 1¼ in. by 3 in.	.20
2 1-in., 8/32—F. H. brass screws	.02
2 8/32-in. brass battery nuts	.02
2 ¾-in., 6/32 F. H. brass screws	.02
2 ½-in., 6/32 F. H. brass screws	.02
2 6/32 hex. brass nuts	.02
2 ⅛-in. brass washers	.01
For Test Receptacle	
1 fibre washer ⅜ in. by 1 in.	.05
1 brass disk 1/16 in. by ¾ in.	.02
1 6/32 F. H. brass screw (length will vary according to make of receptacle used)	.01
	$3.98

The amount of labor necessary for assembling the above at the bench will be one man for 1½ to 2 hr. The amount of labor for installing the testing device will depend upon how far a line must be run to the place where it is being installed.

WM. H. FREDERICKSON.

Elizabeth, N. J.

Inexpensive Clamp for Holding Commutator Together

IT IS frequently necessary to remove a commutator from an armature and keep the copper bars and mica segments in their proper position while repairs are being made, or so that the commutator can be sent to the manufacturer as a sample. In the latter case it is particularly advisable to keep the commutator intact, to indicate the proper diameter; otherwise the new bars and segments may not fit together properly.

Many methods of holding a commutator together are used, but most of them are unsatisfactory. In some shops it is the practice to wrap a piece of copper wire around the bars and twist the wire as tightly as possible. In other shops the bars are wrapped with several layers of friction tape. A third method is to place the armature in a lathe and band the segments carefully with armature banding wire, which is then soldered. This last method cannot be improved upon if the commutator is to be used only as a sample. I offer the following method as being practical and inexpensive, with the added feature of permitting the bars to be tested for electrical defects and repaired.

All mill supply houses sell hanger iron, which is steel strip about ⅛ in. thick and 1 in. wide, with ¼-in. round holes punched at 1-in. intervals. This material is used for supporting steam and water pipes.

A handy commutator clamp may easily be made by cutting off a piece of hanger iron of suitable length with a hacksaw and bending ½ in. or so of each end at a right angle. The strip is then formed around the commutator and a small bolt put through the ends to tighten it. Any kind of thin strip iron could, of course, be used, but when hanger iron is used it is not necessary to drill holes for the holding bolt, which saves time.

The circumference of the commutator may be measured with a piece of twine. Experience will soon show how much to allow for the bends at the ends of the strip. When tightened the ends should be separated about ⅜ in. A steel bolt 1½ or 2 in. long, which fits loosely in the holes in the strip and is heavy enough to stand considerable strain, should be used. A bolt of this length may be loosened to remove a bar for repairs and tightened when the bar is replaced, which will also tighten the commutator. When removing a commutator bar it is well to wedge the opening with a piece of wood or metal, so that in case the workman is called away no one can tamper with the loose segments and thus wreck the whole commutator.

For small commutators one can purchase adjustable clamps, such as are used on the hose connections of automobile radiators, from any accessory store for a few cents each.

If a piece of heavy paper is placed between the steel clamp and the commutator the latter may be tested for short-circuits between the bars.

Cleveland Heights, Ohio C. B. KECK.

New Equipment

for plant operation and maintenance

Industrial plant executives concerned with the selection and operation of mechanical and electrical equipment will be interested in these new devices which are designed to improve plant operation or reduce operating and maintenance costs.

New Electric Space Heater

THE Chromalox line of electric heating units manufactured by Edwin L. Wiegand Co., 422 First Ave., Pittsburgh, Pa., has been increased by the addition of a space heater. This unit, it is stated, was developed to meet the requirements of general air heating where low first cost is a deciding factor. A cross-section of this unit is shown in an accompanying illustration.

This unit has triple-spiral imbedded resistors and a large radiating surface area for general air heating.

These units are 2 ft. long with mounting holes 22¾ in., center to center, and are made in 500-watt units for 110, 220 or 250 volts. If an increase in wattage is not a factor, these space heaters will operate, it is said, on higher voltages.

Worm Reducing Gears for Ratios Exceeding 100 to 1

WHEN using worm gears for ratios above 100 to 1, as required for driving cooling tables, conveyors, stokers, heat-treating furnaces, escalators, and so on, it is often desirable to use two steps, with which the highest reduction ratios ordinarily required are readily attained. The two-stage worm reduction gear illustrated herewith has been developed by the De Laval Steam Turbine Co., Trenton, N. J., for ratios up to 8,000 to 1. The one casing carries all bearings for the high-speed worm shaft, the low-speed worm shaft, which also carries the high-speed wheel, and the low-speed wheel shaft, thereby insuring accurate alignment and perfect meshing. There are only three working members, excluding the ball bearings of the two worm shafts, and these parts are heavy and rugged. End thrust and bending strains from the driving and driven machines are avoided by the use of flexible couplings.

The one-piece casing also acts as an oil reservoir. A positive oil pump draws oil from the reservoir and forces it through passages to the low-speed shaft bearings. Escape of oil along the high-speed worm shaft is prevented by a packed gland, while the seepage of oil along the low-speed shaft is avoided by the use of an oil slinger working between the end of the bearing and an oil guard surrounding the shaft and held in grooves in the casing and cover.

New Thermaload Starter

IN THE new thermaload starter made by the Monitor Controller Co., Baltimore, Md., the thermal expansion units are of thermal metal and it is stated that no liquid of any kind is employed. These expansion units are helically wound, fixed at one end and pivoted, but free to turn at the other end. Actuating arms attached to the free ends of the expansion units transmit their motion to the contact arm of the relay. Movement of this arm under overload conditions opens the relay contacts and breaks the circuit for the holding magnet of the main line contactor. This causes the main line contactor to open and disconnect the motor from the line. It is claimed that an ingenious arrangement of two contacts on the relay, insures flutter-proof operation.

The thermal or heating units of various ratings are interchangeable, thus enabling a starter to be changed from one horsepower rating to another by inserting the proper thermal units. This permits motors to be changed or shifted about without shifting around or changing starters and without disturbing the wiring.

The starter is manufactured in two types. One type has a self-resetting thermal relay and is used with three-wire, momentary-contact control circuits. The second type has the relay arranged for manual reset and may be used with either two-wire maintained-contact or three-wire momentary-contact, pilot-circuit control. The three-wire momentary-contact master stations have the start circuit normally open and the stop circuit normally closed.

Support for 600-Volt Buses

A NEW support for potential and synchronizing buses for 600 volts or less has been announced by the General Electric Co., Schenectady, N. Y. It is said to be made of non-fragile material and is designed to withstand tight clamping.

This support will hold three ¼-in. bus tubes and, with the addition of spacers, will hold three additional tubes. It is furnished with insulating tubes for holding copper tubing but is also adaptable to the use of copper tubing insulated with circular loom.

Automatic Time Switch

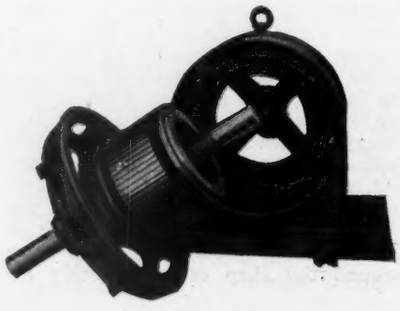
THE Eureka time switch for automatically turning on or off electrical connections, is announced by the Eureka Tool & Machine Co., 42 Walnut St., Newark, N. J. This switch is mounted with a clock on the base of a box, 4⅝ in. by 6½ in. by 3 in., and may be set to operate at any time desired.

Some of the industrial uses are: starting of electric furnaces; controlling heating of lead or other metal melting pots; operation of signs and battery chargers; control of other heating or power equipment which operates on a time schedule. One common use, it is stated, is for turning on heating devices in the morning, so that they will be hot by the time the men commence work, and automatically turning them off again at night to prevent fire from overheating.

Automatic, Self-Starting, Induction Motor

THE Type AA Ideal induction motor is announced by the Ideal Electric & Manufacturing Co., Mansfield, Ohio. It is stated that this motor which is shown in an accompanying illustration, accomplishes magnetically what heretofore has been done by mechanical means. The construction and principle of operation are described by the manufacturer as follows:

The Ideal automatic, self-starting, induction motor is a squirrel-cage induction motor with a double squirrel-cage winding in the rotor. The outer squirrel-cage winding in the top of the rotor slots has about ten times the re-



sistance of the second squirrel-cage winding in the bottom of the slots and during the starting period, furnishes high starting torque with low inrush of current from the line. At the start the frequency of the rotor current is the same as the stator or line current, but gradually becomes less as the rotor begins to revolve and become zero at synchronism or full speed. Since the low-resistance winding is imbedded deeply in the rotor iron, it has high reactance at the start and therefore low current. The outer, high-resistance winding, which is near the surface, has low reactance at the start and, therefore, higher current. As the rotor gains speed the reactance of the inner squirrel-cage winding decreases until at full-load speed it operates like a standard squirrel-cage winding. Because of the great difference in resistances of the two windings, the high-resistance winding carries very little current at full-load speed. Thus the transition or change-over from the starting to the running condition is accomplished magnetically, or simply by a change in the reactance of the rotor.

The manufacturer states that this motor can be started on full-line voltage without the use of a compensator or other current-limiting device. Also, it is said that the starting torque is from 135 per cent to 175 per cent of full-load running torque with full-line voltage impressed on the motor terminals.

Type AA motors are built in any size from 3 hp. to 100 hp., or larger if desired.

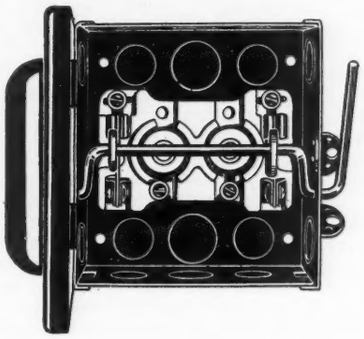
Furnace Charging Tructor

THE success attained in treating heavy pieces of alloy steel has brought a demand for better facilities for handling the output. To keep apace, Elwell-Parker Electric Co., Cleveland, Ohio, has developed a new type of portable, battery-driven furnace charger. This unit is propelled by an Elwell-Parker electric motor and is steered on all four rubber-tired wheels. The drivers are 22 in. by 4½ in. while the trail or smaller wheels beneath the load-supporting forks carry dual-differentiating 10 in. by 6 in. tires.

The load supports consist of two 92-in. by 8-in. horizontal fingers upon which ten 300-lb. packed furnace boxes are placed. The bottom of the furnace is provided with two slots to receive the lower flanges of the fingers. The furnace floor between and at each side of the slots supports the boxes or pots when the fingers are lowered and withdrawn. The furnace is set above the floor to provide clearance for the smaller axle thrust beneath the furnace when charging or discharging. The fingers are secured to two steel arms which are provided with hardened rollers on ball bearings. These rollers travel on renewable ways attached to 8-in. upright channels. The lifts are from 11 to 72 in. high as required.

Two-Pole, Plug-Fuse Switch

THE new Type 33, 30-amp., 125-volt, two-pole, plug-fuse entrance switch, Class B, is announced by The Wadsworth Electric Mfg. Company, Covington, Ky. This switch, which is shown in an accompanying illustration,



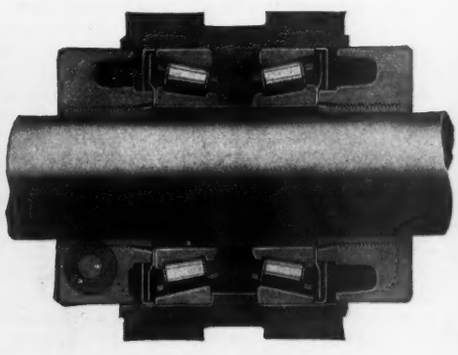
is provided with knockouts in removable end plates at the top and bottom, and in the sides and back of the cabinet. This switch, it is stated, is particularly adapted for small motors, heavy-duty lighting or industrial heating circuits, and many other industrial applications within the capacity of the device.

Roller-Bearing Loose Pulley

FURTHER application of Timken roller bearings to power transmission equipment has been announced by the Dodge Manufacturing Corp., Mishawaka, Ind., in the new Dodge-Timken roller bearing loose pulleys which are now available in both iron and steel. It is said that the problem of lubrication which is always a feature of great importance in loose pulley operation, has been given special attention. In addition, a positive dustproof feature has been provided.

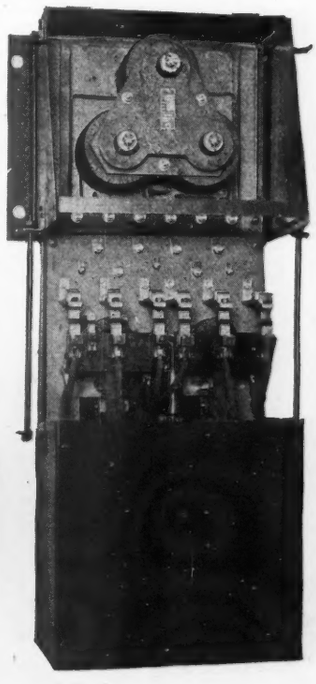
The steel loose pulley consists of an Oneida steel pulley provided with an extra large bore to accommodate a Dodge-Timken roller bearing unit mounting. The pulley is not split, but is riveted at the rim; the clamp hub holds the unit mounting in place. The cast-iron loose pulleys are made from regular, double-belt, solid iron pulley patterns and for diameters up to and including 20 in. the pulleys are counterbored to receive the Dodge-Timken unit mounting which is the same as that used in the steel pulley, except that the hub of the pulley serves as the housing. In diameters over 20 in. the pulleys are bored straight to receive the unit mounting, which is secured by setscrews.

The Dodge-Timken unit mounting consists of two Timken tapered roller bearings mounted on a ground steel tube and fitted to an accurately machined cast-iron housing. Grease seals and two clamping collars are mounted on the threaded ends of the steel tube. The tube is slotted and threaded at each end and is held to the shaft by the two collars which are used to obtain accurate adjustment of the bearings on the steel tube. A cross-section of a pulley hub is shown in an accompanying illustration. It is stated that the special grease seals positively prevent dust working in or lubricant working out. In both steel and iron pulleys a lubricating feed pipe is located between the arms, so as to be conveniently accessible, and is inserted through a hole bored in the pulley hub.



New Impedance Starter for Squirrel-Cage Motors

AN entirely new design of squirrel-cage motor starter that obtains reduced voltage for starting by means of impedance coils in series with the motor primary, instead of the more usual primary resistors or auto-transformers, has been developed and placed on the market by the Rowan Controller Company of Baltimore, Md.



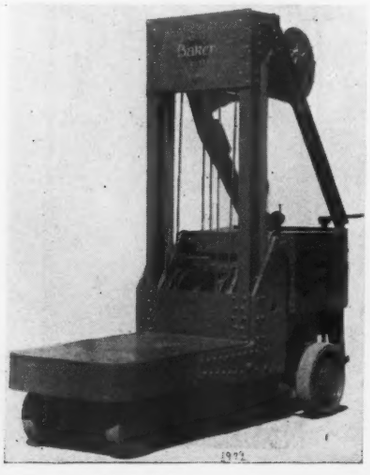
In brief, this starter consists of two sets of contactors that are immersed in oil, three impedance coils which reduce the line voltage, and a start-stop push button switch. Upon pushing the start button, one set of contactors closes and starts the motor on reduced voltage; the closing of the second or running contactor is controlled by the action of a dashpot and the voltage across the motor terminals, which automatically increases as the motor speed increases. It is said that this combination will always start the motor and vary the time of acceleration according to the amount of load on the motor so that the line disturbance will be a minimum.

For protection against overloads, single-phasing, and short-circuits, either a circuit breaker or a combination thermal and instantaneous overload relay panel is provided. The latter will give thermal protection against running overloads or single-phasing, and instantaneous overload protection in case of short-circuits or heavy grounds. In the illustration on page 101 the oil tank has been dropped so as to display the contactors for inspection. Likewise, the cover, hinged to the top of the controller, has been removed to allow inspection of the impedance coils. The starter is said to be practically dust-tight when closed.

Six-Ton High-Lift Truck

THE accompanying illustration shows the new Baker 6-Ton Hy-Lift Truck, being marketed by the Baker-Raulang Co., Cleveland, Ohio. For several years men in the steel stamping and automotive industries have recognized the high-lift type of industrial truck as the most practical machine for changing dies conveniently and at low cost. Naturally, these heavy loads have proven rather destructive to trucks designed to carry 2- or 3-ton loads, but this 6-ton machine has been designed of heavy construction.

The power is obtained from a Baker totally-enclosed series motor driving through a worm reduction and full-floating axle shafts. The hoist is of the two-cable type and the drums are driven by a compound-wound motor through a combination worm and planetary reduction.



Automatic Time Switch

A POSITIVE-ACTING, completely automatic time switch of Swiss manufacture but made to conform to conditions in this country has been placed on the market by The States Co., Hartford, Conn., under its own trade name. These motor-driven switches are said to be applicable to all possible combinations of control or selective switching. The driving motor used with these switches consists, primarily, of a two-pole armature which is arranged to oscillate freely in a constant magnetic field produced by a steel permanent magnet.

The time dials in general are divided into hours and fractions of hours and turn one revolution during twenty-four hours. For comparatively heavy current (75 amp. to 200 amp.) and voltages up to 3,300 a time and cut-out oil switch of the quick-break type is available. The clock movement and driving motor, similar to that described above, are contained in the upper part of the switch in a cast-iron case that may be sealed. The oil container is suspended by four rods, with a screw thread their entire length, coupled together by a linked chain.

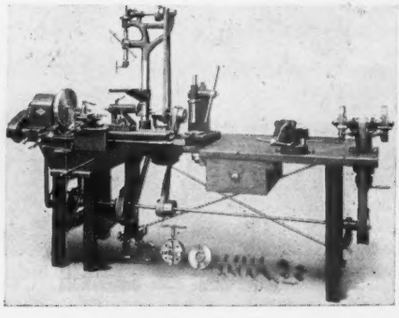
This company is also furnishing an electrical temperature regulating apparatus, which uses one of its time switches in connection with its "Thermo Regulator."

Combination Metalworking Unit

A WORK BENCH on which a lathe, drill press, arbor press, vise and grinder head are conveniently arranged, as shown in an accompanying illustration, has been brought out by the Artisan Manufacturing Co., 839 W. Sixth St., Cincinnati, Ohio. This combination unit, which has the trade name of Artisan Metalworker, is especially designed to meet the needs of the small repair shop, electrical department, or the maintenance department in industries which do not have a metalworking department.

As shown, the various tools are mounted on a hardwood bench top, 7 ft. by 2 ft. 6 in., which is supported on cast-iron legs. The tools are driven from a countershaft extending lengthwise under the bench. This countershaft may be driven either by a ½-hp. motor or may be belted to a lineshaft. The lathe has 11 in. swing over the bed, 16 in. swing over the gap and takes 24 in. between centers; standard lathe tools are furnished with the outfit.

The grinder is equipped with two 6-in. by 1-in. emery wheels which are driven from a flanged pulley on the countershaft. When the grinder is not in use the belt hangs slack but when needed, a double pulley idler is thrown in, thus tightening the belt which drives the wheel.

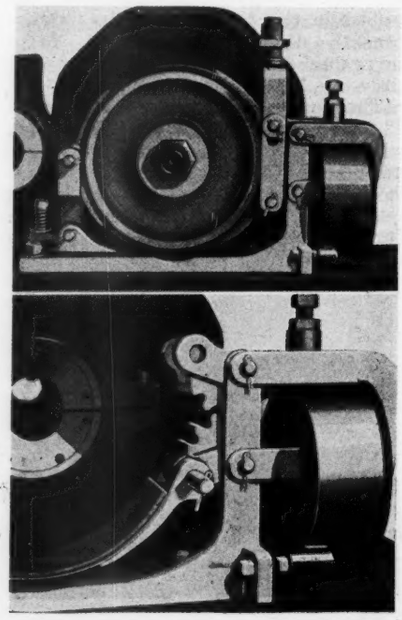


Electrically-Operated Brake

A NEW type of brake for use on electric cranes, elevator motors, electric hoists, motor-driven screw-downs, and similar applications is now being manufactured by the Clark Controller Co., Cleveland, Ohio.

The general appearance of the brake is shown by the top picture in the accompanying illustration, from which it may be noted that the friction band acting upon the brake wheel is divided into two parts, which are duplicates. It is stated that about 89 per cent of the brake wheel surface is utilized for braking. The cylindrical device at the right contains a spring and a magnet for setting and releasing the brake. The action of these two devices is transmitted through the bell crank, which is mounted above the cylindrical device and is pivoted to the frame, as shown in the bottom illustration. This bell crank operates the two geared sectors, shown in detail in the bottom illustration, which in turn tighten or release the friction bands around the brake wheel. The brake is said to be equally efficient in either direction of rotation of the brake wheel.

There are two adjustments, one for the braking torque, and the other to compensate for the wear of the brake lining. Both of these adjustments are easily accessible. The same general design of brake is adaptable for alternating-current operation and also for use as a foot-operated brake.



Practical Books
for your personal library

Every man who aspires to larger responsibilities should build up a professional library containing carefully selected volumes on subjects related to his work. Copies of the books which are reviewed here may be obtained from the publishers mentioned.

Electricity and the Structure of Matter—By L. Southerns, Lecturer in Physics, University of Sheffield. Published by Oxford University Press, London, England, 120 pages, illustrated. Price $1.50 net.

This is one of the series of "The World's Manuals," a group of introductory volumes designed not only for students, but also for the great body of general readers who are sufficiently alive to the value of reading to welcome authoritative and scholarly work presented to them in terms of human nature. About 30 pages are devoted to a historical discussion of the subject up to the discovery of the electron. The remainder of the book covers some of the lesser understood applications of electricity. A glossary of technical and uncommon terms which are used in this volume is included.

* * * *

Rewinding Small Motors—By Daniel H. Braymer, formerly Editorial Director, INDUSTRIAL ENGINEER, and A. C. Roe, Industrial and Insulation Engineer, Renewal Parts Engineering Dept., Westinghouse Electric & Mfg. Co. Published by McGraw-Hill Book Co., Inc., 370 Seventh Ave., New York, N. Y., 240 pages, illustrated. Price $2.50.

Readers of INDUSTRIAL ENGINEER need no further introduction to these authors. Much of the information in this book has appeared in early issues of INDUSTRIAL ENGINEER; it has, however, been rearranged in this volume and much material added for the purpose of making it as useful as possible to practical men either with a greater or less amount of experience.

The authors have compiled in this volume practical information on winding procedure for fractional horsepower, direct- and alternating-current motors. This discussion includes all the common types of windings used for portable drills, grinders, automobile starting motors, sewing machine motors, desk and ceiling fans, vacuum cleaner and washing machine motors, and other similar applications of these small units.

The information has been presented in step-by-step details from the start to the finish of a winding job so as to make it easy for the experienced winder to understand the procedure and give him a grasp of the essential requirements of the windings that are used by the manufacturers of small motors and so enable him to rewind or change them as conditions require, even though he may not have had much experience in the rewinding of small motors. The practical side of the winding operation has been dealt with in detail, giving as little technical information as is required to understand the reasons for the winding procedure that is presented. This is intended to be a practical man's handbook on the subject, although it will be found to be a useful reference book as well.

* * * *

Health Maintenance in Industries—By J. D. Hackett, formerly Manager, Medical Department, Nichols Copper Co. Published by A. W. Shaw Co., Chicago, Ill., 477 pages, illustrated with tables and charts. Price $5.

The object of this book is to show those who manage plants how the workers' health may be maintained and improved as a means of increasing production. The subject is treated simply and its medical and surgical aspects are dealt with only in so far as may be necessary to their understanding from the plant manager's point of view.

Considerable attention is given to plant hygiene and plant sanitation. Entire chapters are devoted to the following subjects: Ventilation, heat and heating, plant lighting, food and lunch rooms, fatigue removal, rest periods and seating, toilet facilities and sanitary standards, washrooms and washing facilities, lockers and locker rooms, laundry and cleaning, drinking water, occupational dusts and diseases.

* * * *

Electrical Machinery Erection — By Terrell Croft, Consulting Engineer. Published by McGraw-Hill Book Co., Inc., 370 Seventh Ave., New York, N. Y., 306 pages, illustrated. Price $3.

The practical methods and processes used in modern practice in the mechanical installation of electrical machinery, from the unloading of the apparatus from the car to its final fixing and aligning in its ultimate operating location, are discussed in this book. Some of the subjects included are: unloading and moving, supporting, erecting, locating, and fixing electrical machinery. A section of the volume is devoted to the mechanical maintenance of electrical machinery, particular attention being paid to the bearings.

* * * *

Power Plant Lubrication—By William Farrand Osborne. Published by McGraw-Hill Book Co., Inc., 370 Seventh Ave., New York, N. Y., 262 pages, illustrated. Price $3.

The purpose of this book is to present, in such a way as to be of the greatest possible value and practical use, the principles of lubrication and the solution of lubricating problems which have been worked out by the author. It will be of value to everyone who is interested in the operation of machinery or the purchase of lubricants. Because the whole subject of lubrication is so broad and involves so many details, both as to theory and practice, the subject matter has been confined to the practical requirements of power plant machinery. However, with the general principles of lubrication of such machinery firmly in mind, the application of these principles to other types of machinery is comparatively simple.

Part I is devoted to a discussion of the physical and chemical properties of lubricants, their action under the changing influences of heat, pressure, and so on, and the methods of determining their relative magnitude and value. Part II covers the practical applications of lubricants to the principal types of machinery commonly found in power plants. Part III contains specifications of lubricants which have been found suitable for many types of service and are recommended to purchasers of lubricants who wish to buy in this manner. Standard methods of testing lubricants are also given.

* * * *

Light, Photometry and Illumination Engineering—By William E. Barrows, Professor of Electrical Engineering, University of Maine. Published by McGraw-Hill Book Co., Inc., 370 Seventh Ave., New York, N. Y., 400 pages, illustrated. Price $4.

This book has been designed as a text in illuminating engineering and as a reference work for the practical engineer. It is an outgrowth of the author's previous books, "Electrical Illuminating Engineering," and "Light, Photometry and Illumination." However, approximately two-thirds of this text is new.

It has been the aim of the author in this book to assemble the latest ideas and thoughts available on the subject of artificial illumination and the choice of lighting equipment. Much information on present practice will be found in the chapters on the different classes of lighting. Various types of lighting installations are discussed, and numerous charts, diagrams and tables, as well as illustrations, give the theoretical and practical sides of illumination.

* * * *

Coils and Magnet Wire—By Charles R. Underhill, Consulting Electrical Engineer. Published by McGraw-Hill Book Co., Inc., 370 Seventh Ave., New York, N. Y., 474 pages, illustrated. Price $4.

All power transmission lines begin and end in coils. The problems involved in the use of electrical conductors and electrical insulation are common to all forms of coils regardless of the use to which they may be applied. Therefore, in this volume, particular stress is placed on the conductor and the insulation. The subject of magnet wire is thoroughly treated, also. Much space is devoted to the composition and application of wire enamel and its properties as a film, as well as the usual cotton, silk, paper and asbestos coverings as applied to magnet wire.

Internal and external insulation of coils receive the consideration their importance deserves. Methods of designing various coils are described. Some of the conventional methods of winding and finishing coils are treated in a general way, and some in detail. Because the small details that are so easily overlooked are usually the causes of failure of coils, and therefore of the entire apparatus or machine of which such a defective coil is a part, considerable emphasis is placed throughout the text upon points that need watching.

Trade Literature
you should know about

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of bulletin or catalog desired, as given in these columns.

Electric Machinery Catechism—Bulletin H338 carrying the above title, presents in a simple way in a 36-page, question-and-answer discussion the most important theoretical and practical features of the common types of d.c. and a.c. motors, generators, and control equipment. Numerous charts and illustrations are used.—Fairbanks, Morse & Co., 900 S. Wabash Ave., Chicago, Ill.

Heating and Ventilating—Recent circulars show the use of the Ventura disk fan in connection with unit heaters and for ventilation of industrial plants.—American Blower Co., Detroit, Mich.

Grounding Devices—A number of loose-leaf sheets illustrate, describe, and price the various types of Groundulets for facilitating the making of ground connections wherever necessary.—Groundulet Co., 86 Park Place, Newark, N. J.

Arc Welder—A 24-page bulletin discusses arc welding and gives the particular advantages claimed for the Lincoln Stable-Arc welder. Various units are illustrated and described.—The Lincoln Electric Co., Cleveland, Ohio.

Battery Charger—Bulletin 6561 describes a line of individual and multiple motor-generator sets for battery charging.—The Hertner Electric Co., W. 113th St., Cleveland, Ohio.

Roller and Ball Bearings—Bulletins describe the line of Hoffmann Precision roller and ball bearings, and single- and double-ball thrust bearings, for heavy loads and hard service. Several pages are devoted to a discussion of the lubrication and instructions for mounting.—Norma-Hoffmann Bearings Corp., Stamford, Conn.

Mica Undercutters—Circulars describe the No. 6 type of Hullhorst mica undercutting machine and disk type of mica cutter.—The Hullhorst Micro Tool Co., Dept. 2, Toledo, Ohio.

Pipe Threading—A circular describes the No. 4 Beaver power-driven, pipe-threading tool which will handle from ¼-in. to 2-in. pipe and, when used with a special universal shaft and Beaver die stocks, pipe up to 6 in. in diameter.—The Borden Co., Warren, Ohio.

Screw Pumps—A circular describes Quimby screw pumps which are used for handling various heavy liquids and semi-liquids, such as oils, tar, molasses, soap, and so on, at high pressure.—William E. Quimby, Inc., Parkhurst St., Newark, N. J.

Bus Supports—A series of bulletins describe various types of bus supports and disconnecting switches.—Electrical Development & Machine Co., Holmesburg Junction, Philadelphia, Pa.

Wall Chart—A 17-in. by 25-in. wall chart contains a number of useful and practical tables, such as, a copper wire chart, allowable carrying capacities of copper wire and cables, common insulating materials, decimal equivalents, drill sizes, condensed tables of trigonometric functions, and other tables. This will be mailed to any user of insulating material when requested on his business letterhead.—Mitchell-Rand Mfg. Co., 18 Vesey St., New York City.

Light Globe Removers—A circular describes four different types of portable apparatus for charging electric light globes in places difficult of access.—Pierpoint Mfg. Co., Lock Box 195, Pana, Ill.

Grinders, Buffers and Polishers—Catalog 825 describes the line of C. A. W. motor-driven grinders, buffers and polishers. These have a double head, with the motor mounted in the head, and Timken adjustable, taper roller bearings.—Cleveland Armature Works, 4732 St. Clair Ave., Cleveland, Ohio.

Electric Trucks—A circular describes the line of Wright-Hibbard power-operated, elevating-platform trucks which are especially built for narrow passages and short-radius curves.—Wright-Hibbard Industrial Electric Truck Co., Inc., Phelps, New York.

Automatic Electric Control—Circulars describe the No. 848 Mercoid Control, industrial type, which is used to automatically open or close an electric service circuit, feeding motors of 1 hp. or less, upon a change in temperature, pressure, or vacuum.—The Federal Gauge Co., 564 W. Adams St., Chicago.

Wire Stripper—A circular describes the Acme electric cord and wire stripper, a hand tool which can be set for various sizes of wire.—A. Laubscher, 77 Fort Pleasant Ave., Springfield, Mass.

Threadless Conduit Fittings—A booklet entitled, "A Message for You of Economic Importance," illustrates a number of the special Knodu-Box threadless conduit fittings, shows how they are applied and gives some interesting figures concerning the cost of installation of threaded and threadless conduit fittings.—Erie Malleable Iron Co., Kondu Division, Erie, Pa.

Splices and Tapes—A 14-page booklet describes various tapes and other insulating materials and explains and illustrates in detail how to make a splice on rubber-insulated wire.—The Okonite Co., Passaic, N. J.

Industrial Ovens—A circular describes the Type I Freas electric industrial oven, thermostatically controlled, for industrial baking, drying and other uses.—The Thermo Electric Instrument Co., 8 Johnson St., Newark, N. J.

Lighting and Other Electrical Products—Catalog 24 covers the complete line of Benjamin electrical products. Sections of especial interest to industrial plant men are: Industrial illumination data, reflector brackets, various lines of lighting equipment, industrial signals, heavy-duty, water-tight wiring devices, and others.—Benjamin Electric Mfg. Co., 120-128 So. Sangamon St., Chicago, Ill.

Flexible Coupling—A circular shows the construction of the Falk-Bibby flexible coupling and gives some examples of its use under heavy service. These couplings are made in capacities ranging from 1/3 to 20,000 hp. at 100 r.p.m. rating.—The Falk Corp., Milwaukee, Wis.

Electric Heat in Industry—A 32-page illustrated bulletin, GEA-261, carrying the above title, deals with the advantages of electric heat for various industrial applications, including the metal industry, heat-treating, ceramic industry, chemical industry, printing industry, finishing processes, and other such uses.—General Electric Co., Schenectady, N. Y.

Pyrometers—A 56-page catalog, Part-4000, describes and illustrates the complete line of Tycos pyrometers and charts. Several pages are devoted to a discussion of the selection of a pyrometer, principles of operation, application, method of installing the thermocouple, maintenance, testing and engineering data.—Taylor Instrument Co., Rochester, N. Y.

Speed Reducers—A circular describes a line of Herringbone continuous-tooth speed reducers which are made up to 150-hp. capacity and in reduction ratios up to 250 to 1.—Foote Bros. Gear & Machine Co., 236-246 N. Curtis St., Chicago, Ill.

Motor Fuse Rating Card—A convenient card for posting up, tabulates the full-load current, indicates the correct rating of starting and running fuses for properly protecting different types and sizes of motors, and gives other information.—Chicago Fuse Mfg. Co., 1511 W. 15th St., Chicago, Ill.

Conveying Machinery—A 24-page monthly bulletin entitled "The Labor Saver" is devoted to descriptions of installations of labor-saving conveying machinery and of new units of conveying and elevating machinery as they are developed.—Stephens-Adamson Mfg. Co., Aurora, Ill.

Dust Collectors—Bulletin S-125 illustrates a number of Sly dust arresters in different industries and shows their construction and operation.—The W. W. Sly Mfg. Co., Cleveland, Ohio.

Safety Switch—Circular describes the Super-Safety electric switch in various types and capacities.—Super-Safety Switch Co., 1219 W. 103rd Pl., Chicago.

Non-Metallic Gears—A 26-page bulletin describes several installations of Celeron non-metallic gears operating under severe service conditions and gives considerable information on turning and cutting these gears.—Diamond State Fibre Co., Bridgeport, Pa.

Insulation Resistance Testing—A circular describes the Cory-Record Ohmmeter which is used for testing the insulation resistance of electrical apparatus or cables.—Chas. Cory & Sons, Inc., 183-7 Varick St., New York City.

Motion and Operation Recorders—Catalog 1600 describes the Bristol mechanical and electrical motion recorders which automatically record the actual operation, the time of operation, and the extent of mechanical movement of machinery, elevators and hoists, conveyors, opening and closing of doors, gate valves, and so on.—The Bristol Co., Waterbury, Conn.